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THE CHILD'S HEREDITY

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By
PAUL POPENOE



BALTIMORE
THE WILLIAMS & WILKINS COMPANY
1929

HQ 753
.P82

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Made in United States of America

Published July, 1929

COMPOSED AND PRINTED AT THE
WAVERLY PRESS, INC.
FOR
THE WILLIAMS & WILKINS COMPANY,
BALTIMORE, MD., U. S. A.

By PAUL POPENOE



APPLIED EUGENICS (in collaboration with
Roswell Hill Johnson).

MODERN MARRIAGE—*A Handbook.*

THE CONSERVATION OF THE FAMILY.

PROBLEMS OF HUMAN REPRODUCTION.

EUGENIC STERILIZATION IN CALIFORNIA.

STERILIZATION FOR HUMAN BETTERMENT
(in collaboration with E. S. Gosney).

PREFACE

This is a guide-book for parents. Their interests and practical needs have determined the selection, the arrangement, and the treatment of the material. This should be borne in mind by readers whose concern with the subject is less professional.

Racial differences are mentioned only incidentally, a more systematic treatment of them being left for *Applied Eugenics*.

For criticisms and suggestions, I am much indebted to Dr. Sewall Wright, associate professor of zoölogy, University of Chicago; Dr. Charles H. Danforth, associate professor of anatomy, Stanford University; and Dr. Karl M. Bowman, chief medical officer, Boston Psychopathic Hospital.

I am also under great obligations to Mr. E. S. Gosney of Pasadena, in association with whom I have been making a study of the workings of the California eugenic sterilization law during the past three years. Material gathered in the course of this study has been used freely in the present book.

PAUL POPENOE.

Pasadena, January 24, 1929.

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CHAPTER I

THE NEW-BORN BABE

A new-born baby lies wrapped in warm blankets in a basket near his mother, from whom he has emerged a few moments before. Red and wrinkled, he is not wholly an object of beauty, even to his doting parents. Yet there are three things about him that particularly endear him to those parents:

1. He is alive.
2. He is *their* baby.
3. He is different from every other baby ever born.

And those three facts, properly interpreted, tell the whole story of heredity.

Being alive, he is active; for life and activity go together. When the father lifts a corner of the blanket he sees his son in continuous, though slight, motion. These early activities of the infant did not require any practice—they were literally born in him, and indeed are not subject to his control.

More prolonged observations, such as relatives will enjoy through the window of the hospital nursery during the next few days, reveal a number of responses which baby makes to various stimuli, internal or external.

Any part of the body may move: hands and feet, arms and legs, trunk, head, eyes, mouth. None of these responses is more interesting than the power of grasping, which the infant possesses as soon as he is born, though he has certainly never had occasion to grasp anything in his lifetime. Many babies can support the full weight of the body with either hand for a period of time varying from a fraction of a second to almost a minute; even though they have not strength to hold up the head unaided. Often they refuse to perform unless angered by having the head held firmly for a moment; and they lose the ability in a few weeks or months, not to regain it for a year or two.

Sneezing and hiccoughing can both be done to perfection by even the youngest infant; indeed, he sometimes practices the latter while still in the uterus, though naturally not the former, because his lungs are collapsed until after he gets his head outside the maternal birth canal and fills them with air at the time of his first cry, which is often the first sign of life that he gives.

Defecation, voiding of urine, and erection of the penis all occur immediately after birth, sometimes before.

But the movements on which most interest is centered, both by the infant and by the onlookers, are those of the mouth. This organ is, indeed, for some months the central feature of the babe's existence, from one point of view.

It is in motion much of the time, and within a few days it assumes shapes that are interpreted by the relatives as smiles. The child does not smile deliberately, as a response to the antics of his kinfolk, for a month or two yet.

From the moment of birth, the mouth is capable of the sucking reflexes, which are adapted perfectly to draw milk from the maternal fount. Although many an infant has not (as lower animals have) sense enough to seek the breast for himself, but would starve to death lying with his face against it, he knows what to do immediately the nipple is placed in his mouth.

These movements connected with nursing form a complex series which is worth considering for a moment as an illustration of the way the unlearned responses take place. Reduced to simplest terms, the performance is something like this:

1. The baby gets the nipple between his lips.
2. He forms a vacuum in his mouth, largely by movements of the tongue and cheeks. The pressure of the atmosphere on the mother's breast, at the rate of 14 pounds to the square inch of skin surface, then forces the milk out of the breast.
3. The contact of the milk with the infant's mouth excites tongue and cheek movements which push the fluid back to the throat. This is a specific response to a warm fluid tasting like milk. It would not be excited by warm coffee or cold lemonade.



FIG. 1. HOLDING ON FOR DEAR LIFE

This Negro baby, not yet two weeks old, can support the entire weight of his body by his arms. Such an ability (which most babies have) is of no use to him now, but it was a matter of life and death to his ancestors who lived in trees millions of years ago. Hence the capacity became so thoroughly established in his germ plasm that it persists to this day. Photograph from the *Journal of Heredity*.

4. The arrival of the milk near the opening of the throat excites the muscles here, which push it on down, shutting off the windpipe and opening the esophagus at the same time.

And so on, in a long series of almost incredibly complicated nature, involving the most remote activities of nerves, muscles, body fluids, and in fact the whole baby.

It is an endless chain of reflexes. Nerve impulses or currents started in the mouth, by milk and nipple contacts, traverse paths through the nervous system that are laid out and established in working order even before the child is born. They are ancestral patterns: they are inherited.

No one denies this. I rehearse it here because the same sort of inherited mechanism, that is, the same system of open paths and easy transfers through the nervous system, also explains the inheritance of innumerable other traits that appear later.

The baby then is born with an equipment of abilities which, if not unlimited, is at least more or less adequate to his needs; and it is an equipment which grows as he grows, so that as he meets each new problem in the future, he finds himself more or less prepared to grapple with it.

No two babies are alike in these respects any more than they are in appearance. The differences of both kinds—peculiarities of appearance and capacities that depend on the nervous system—go back far into the fetal life.

Racial differences appear distinctly as early as the third month after conception, and individual differences make their appearance at the same time. The human body is just as variable in the uterus as it is in adult life. In other words, individuality is just as definite a few months after conception, and long before the effects of surroundings, of training, and of teaching, have had a chance to exert whatever influence they can, as after the body has been exposed to them for a lifetime (336).¹

¹ Numbers in parentheses refer to the list of references on page 280. These references refer either to original investigations, to critical reviews of such investigations, or to more extended popular articles on the same subject. No

When marked differences between babies thus appear six months before they are born, it is a fair assumption that these differences are much more the result of differences in the material of which these babies are made, than they are of the effects of climate, or exercise, or will power: that is, that they are inborn and little influenced from outside, in comparison with differences in language for instance—the ability to speak at all depends on the inheritance of certain capacities, but whether one speaks English or American depends wholly on surroundings, ambition, and training.

It is a fair assumption, I say, that such differences are part of the child's original nature. But it is merely an assumption, to be tested in each case by the facts. Not everything that is evident at birth—not everything congenital, in a word—is inherited. The baby might be born with smallpox, but no one would call this inheritance. His mother had smallpox, and he was infected in the uterus, just as he might have been 10 years later by contact with an infected person.

Most cases are not so simple. Thus every baby is born with short legs, in proportion to the length of trunk and arms. His parents may have notably long legs. The short legs, though congenital, may not be inherited. They are, in general, due partly to the fact that the legs are not so well nourished in the uterus as is the rest of the body. Part of the blood supply goes through other portions of the body first, reaching the legs last after some of the nourishment it contains has presumably been removed by head and trunk. The force of gravity may also play a part in the result: the child is standing on his head and it is easier for the blood to circulate through the lower part of the body than through the upper extremities. The short legs also seem to be a reminiscence of some ancestral period through which the child has to pass in

attempt has been made to give a complete bibliography, since this book is not intended for the specialist (one of those persons who "knows more and more about less and less"). But on controversial subjects I have tried to give enough references to point the way to further knowledge for any interested reader.

covering, during a few years, the space that the race has covered in millions. The short-legged baby has somewhat the proportions of many of the higher apes; and some human races have retained these proportions, while others have become specialized in the opposite direction. There are, then, a great many different factors that contribute to these short and weak baby legs. The poorer growth of the legs is not due to lack of exercise, for they have had more than any other part of the baby's body, as any pregnant woman will testify when the little heels are beating a tattoo inside her abdomen.

To determine whether or not the short legs are inherited in the ordinary sense, one must give them a chance to grow to their full potentiality. If the child has plenty of good food and a wholesome, hygienic life until he is past adolescence, and if his legs are still short, it is a good guess that he inherited short legs. But if, under those conditions, he grows into the usual rangy and long-legged boy, it is more than a guess that the short legs with which he was born were merely a stage in development.

This, like scores of other familiar facts that might be recalled, illustrates the real nature of inheritance. The child does not inherit any definite *thing*; he inherits merely a *potentiality* of developing to a *certain degree* under *normal conditions*. He can never exceed the limits of this potentiality, but he may, and often does, fall short of them; he does not get the most out of his heredity because the conditions are not favorable to the development of his possibilities. This is fortunate if the possibility is an injurious one, unfortunate if the possibility is a useful or desirable one. The whole of education consists merely in trying to make conditions as favorable as possible for the good potentialities and as unfavorable as possible for the bad ones,—“goodness” and “badness” being determined by the needs of civilization.

If many undeniably inherited traits are represented in the new-born baby only in an early stage of development; if his eyes and hair may change color, his legs change their proportions, his nose change its shape, his teeth appear out of smooth gums, and so on;

it is equally true that many undeniably inherited traits are not evident at all in the new-born. Thus a child may inherit the peculiarity of having gray hair at an unusually early age; but there is nothing in his appearance at birth to prove it.

It is, therefore, absurd to say that every child (or any child) is born healthy, and that all the parents and the doctors have to do is to keep him healthy,—an argument often used to support “infant mortality campaigns.” Such an idea belongs to the philosophers of the eighteenth century,—not to go back to Confucius. Thus Jean Jacques Rousseau began his *Émile*, a treatise on education (1762), with the words, “Everything is good as it comes from the hand of the Creator; everything degenerates in the hands of man.”

One might as well say that, because a child is born without gray hair or wisdom teeth, all the parents need to do is to give him plenty of spinach, sunshine, and certified milk, and he need never have gray hair or wisdom teeth. One would not expect a child to be born with scarlet fever, rickets, pneumonia, convulsions, and the other enemies of childhood. But it is none the less true, as I shall show later, that he is born with some definite relations to these diseases.

It is, then, not possible to get a clear idea of heredity so long as one looks only at the adult, still less at the infant. Such an attempt to view the subject from the outside leads only to confusion and question-begging.

But if, following the method of modern science, one looks at the subject from the inside, it becomes relatively simple. Attention is then focussed on the germ-plasm, on the individual germ-cells which give the baby his start.

The ancient Athenians, and perhaps many earlier generations, exercised themselves over the question which came first, the owl or the egg? Such a question is no longer put, for it is now well understood that owls do not produce eggs. The egg produced the owl, and also produced the other eggs. The eggs go on in an unbroken stream, which started with the first appearance of life on



FIGS. 2, 3. ANOTHER ECHO OF THE PAST

This healthy Portuguese girl was born with a tail 51 mm. long, 10 mm. in diameter at the base. It contains no bone. Every human embryo has a tail at an early stage of its life in the uterus, but it is not often that the tail persists as in this case. Photographs from Dr. J. A. Pires de Lima, director of the Institute of Anatomy, Faculty of Medicine, Porto, Portugal.

the world. The egg is everything, the owl a by-product. Every egg comes from some other egg; the owl is merely a package in which it is delivered.

Here are half a dozen eggs in a saucer. Even an expert, looking at them, would not venture to say what they will become. Given the appropriate kinds of food to grow on—and nothing else—one will become a whale, one a baby, one a cauliflower, one a starfish, one an earthworm, and one a cockroach.

It is plain enough that each egg has its own particular constitution, which causes it to develop into something different from the product of any other egg in the world: for though the products of whale egg and cockroach egg are widely different, yet the products of two successive eggs from one woman are not exactly the same, even if they have grown alongside each other into children born only a few minutes apart as twins. One of them may be a brown-eyed, mild-tempered, patrician girl, a "violet-crowned, pure, sweetly-smiling Sappho" such as Anacreon celebrated; the other a blue-eyed, pug-nosed boy with the disposition of a mustang,—“half horse, half alligator” like Andrew Jackson’s soldiers at New Orleans.

The constitution of the germ-cells, then, determines not merely whether the fertilized egg will develop into a cauliflower or a cockroach or the Hope of the White Race; but it determines, in the first instance, the ways in which that particular cauliflower, or cockroach, or Hope, will differ from every other cauliflower, or cockroach, or Hope.

The most striking thing about the constitution of the cells is that it continues from generation to generation with so little change. A cauliflower always produces another cauliflower—it never produces a cockroach. There are slow changes, spread over millions of years—these make up evolution. There are slighter changes almost incessantly—these make up variation. But the real changes are much less frequent than is sometimes supposed, for nearly all the differences between children and their parents are due

not to any actual alteration in the germ-plasm, but merely to re-combinations of the characters of the two parents.

This germ-plasm (which is merely a general name for the stream of germ-cells) has been going on from generation to generation, in an unbroken stream, since the beginning of life.

It is the oldest thing in existence.

It is the least changeable thing that lives.

It is the only immortal thing alive.

But it is time for the new-born baby, who was left in his basket a few moments ago, to be given his first bath and moved to his nursery.

1. He is still very much *alive*, because he is the product of this germ-plasm—he is a part of the life-stuff of the world.

2. He is justifiably regarded by the parents as *their* baby, because he is the product of the union of the two strains of germ-plasm of which they, respectively, are the temporary custodians.

3. He is *different* from every other baby ever born because, owing to the mechanism which I will describe in the following chapters, no two germ-cells can ever be identical,—even though they are fundamentally alike through their similarity of constitution.

The germ-plasm consists merely of germ-cells. They are dividing all the time: one becomes two; the two become four; the four multiply to eight, and so on in what appears to be an infinite series. Nearly all of them die. Perhaps one in many billions finds the opportunity to survive and perpetuate the chain of life.

Yet despite this endless series of cell divisions, the thread is never broken. Whatever it is that the cell contains, this content is passed on virtually unaltered, so that after an almost uncountable number of generations the latest cell is ready to produce, from the same old pattern, another model. If it is a cauliflower, it will be recognized at once as a cousin of the cauliflower that was produced from the same series a million cell-generations ago. If it is an antiseptic baby, whom five white-clad attendants wrap in the sterilized blankets of a modern hospital, it will be recognized at once

as a cousin of the baby whom the cavewoman delivered unaided and laid among the fleas of a wolf skin on the floor beside her sooty fireplace.

The offspring is, broadly speaking, true to type. It is the product of heredity.

Heredity, then, may be defined as the persistence of certain constituents in the germ-cells, through an endless number of cell divisions. ✓

CHAPTER II

THE CHILD'S RELATION TO HIS ANCESTORS

Since every child, in addition to having two parents, also possesses four grandparents, eight great-grandparents, 16 great-great-grandparents, and so on back forever, the number of ancestors doubling in each generation; it is not necessary to count through many centuries to get an overwhelming number of forebears.

Thus if William the Conqueror is separated from the present by 24 generations, it would appear that any infant of British extraction must have had 16,000,000 ancestors at the time of the battle of Hastings. Yet there were not as many inhabitants as that in all Britain and France put together!

If one goes back to the days of Jesus, the number of calculated ancestors becomes some 18,000,000,000, although the Roman empire at the time of its greatest extension, under Trajan, had not over 100,000,000 inhabitants. And yet that period was only a few minutes ago, in the whole history of life on the globe.

Moreover, many of the ancients have no descendants in the present generation. Some of them died unmarried, others married but were childless; and the effect of these eliminations, carried through several generations, is to cut off lines of descent rapidly. Once gone, such a line is gone forever. The consequence is that after a few centuries the population becomes more and more predominantly made up of the representatives of certain stocks that are fecund.

Obviously, if these self-perpetuating families differ in some way from those that die out (and they always do differ in many important ways), the whole character of the population will undergo a slow but steady change. That forms the problem of eugenics. Here I am concerned only to point out that lines of descent are disappearing all the time: so that if one could trace his ancestry back to Charlemagne, he would not find his patrimony spread out

evenly among all the inhabitants of Europe in the ninth century A.D., but would discover the lines gathering together into bundles and ending in relatively few of the people who then possessed the earth.

It is clear enough that even though every child be "heir of all the ages," he is not the descendant of all the people who lived in those ages, but perhaps of a minority. A few progenitors must be repeated, over and over and over again, in the pedigree.

Just as ancestors multiply rapidly when one counts back, so descendants multiply with equal rapidity when one counts forward. Thus William the Conqueror ought to have some 16,000,000 living descendants, a fact which deprives the claim to descent from him of any great value,—although it is rarely enough that anyone possesses the necessary documents to show the actual line of descent unbroken in all the generations intervening.

In the same way it can be computed easily that the little band of Pilgrims who came in the Mayflower to Plymouth Rock in 1620 must have literally millions of descendants in the existing population of the United States, even though only 33 of the original number founded families.

From the fact that a man six generations ago may now have 12,000 or more living descendants, it follows that the posterity of Jonathan Edwards on the one side, of Max Juke on the other, should not ascribe much of their importance to their eponyms, even if there has been a deal of consanguineous marriage since. What their pedigrees really show is the tendency of traits to run in families and social classes, not in a given line of descent.

When two persons who can trace back to a common ancestor, no matter how remote, marry each other, they are marrying their cousins. C. B. Davenport calculated that virtually all the old Americans are related to each other not more distantly than thirtieth cousin, and most of them at least as close as fifteenth cousin. As one gets into other races, the relationship becomes more distant, but it is still a relationship. Adam or no Adam, the human species is distinctly one big family.

Thus it is easy enough to see why people are, in essentials, all alike. They all have legs, lungs, livers, and lips for the same reason that their ancestors all had legs, lungs, livers, and lips. The foundations for these things, and the other fundamental features that go to make up every man, or indeed every animal, are deep in the germ plasm—so deep that they can not now be got out.

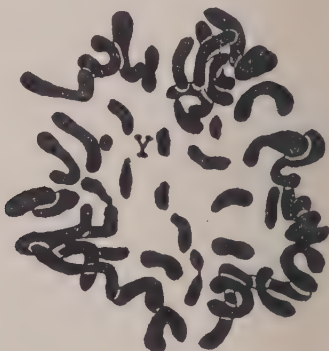


FIG. 4. THE HUMAN CHROMOSOMES

Each of these little rods consists of a string of genes. They are, therefore, the carriers of the heredity; they may be called the germ plasm. Among the 48 chromosomes in this cell (taken from the testicle of a white man), the X chromosome is visible, at the upper left-hand corner of the letter "Y" that has been inserted; to the left just below it is the small round Y chromosome. If the cell had been taken from the body of a woman, the Y would be absent, a second X taking its place. Illustration from Dr. Theophilus S. Painter, professor of zoölogy, University of Texas.

In fact, these things are so much a matter of course that they are not even thought of as being part of the child's heredity. No one remarks that John has two legs, just as his father has, or that Jane resembles her mother in having an ear on each side of her head. But John may be said to have unusually long legs, like his father, or Jane to have particularly small and beautiful ears, like her mother. In popular usage, heredity deals not so much with fundamentals as with superficia, and not so much with resemblances as with differences.

Studying the subject systematically, one can proceed in no other way than by studying the differences. When one has said that both John Sr. and John Jr. have livers, one has very nearly exhausted the liver as a subject for small talk, if one is confined to a consideration of likenesses. But if one begins to note the ways in which these livers differ from each other, and in which the two of them agree to differ from outsiders, then the conversation may be kept going until the party rises from the dinner table.

The practical study of heredity is therefore reduced to a study of individual differences and their correlations. This is one of the reasons why the old definition of heredity as resemblance from one generation to another ("like begets like") is inadequate.

The idea of the continuity of germ plasm explains without any further discussion why people are people and equally why "pigs is pigs." To understand why people differ from each other, and why one pig has red hair, another white, one must go more deeply into the constitution of the germ plasm. Studied from this point of view, each germ cell is found to be composed of two parts.

The bulk of it consists of a quantity of protoplasm which is complicated enough in its structure, but which serves mainly as a background and vehicle for the second part, and may therefore be disregarded in the present discussion. The second part is a central nucleus.

Properly stained and studied, this nucleus is found to contain some material that, at certain stages in the life history of the cell, is gathered into threads or rods that are easily visible. These rods are called the chromosomes, and so far as is known they are the actual carriers of the heredity. They are, therefore, essentially the germ-plasm, which is handed on from generation to generation, unchanged and yet continually changing; incessantly destroyed yet potentially immortal.

The rest of the cell has important parts to play in the development of the individual, but the chromosomes cast the deciding vote at every stage of the proceedings, and little error will be involved in centering this discussion on them.

The number of chromosomes in a cell differs with various species, ranging from one to 200 or more, but is normally the same for all members of the species. Thus the little fly, *Drosophila*, which is commonly found on decaying fruit, has eight chromosomes (or four pairs), the frog 24 (12 pairs), the human baby 48 (24 pairs),—a relatively high number which may represent a doubling of a smaller number at some time in history. As chromosomes are small and continually getting tangled, it is much easier to follow the evolutions of eight under the lens than to watch 48. For this reason, among others, *Drosophila* has made much greater contributions to the knowledge of heredity than has even the smartest baby.

In every animal or plant that reproduces sexually, the new embryo originates in the union of a germ-cell from each of the parents. This would double the number of chromosomes at every union. Thus if a baby started from the union of an ovum and a spermatozoön, each containing 48 chromosomes, he would be made up of cells each containing $48+48=96$ chromosomes; his children would contain 192, his great-grandchildren 568, and so on. In no time at all, babies would be stuffed so full of chromosomes that they would burst before they were born.

To avoid such a catastrophe, the germ cells divide before they unite. Every cell in the human body, including the immature germ cells in the testicle or ovary, contains 48 chromosomes, 24 pairs. But when the germ cell matures preparatory to union with one of the opposite sex, it divides in such a way that one of each pair of chromosomes goes into one of the daughter cells.

The method which has been worked out somewhere away back in evolution, to divide these chromosomes, is ingenious. The 48 chromosomes first arrange themselves in 24 pairs, and each pair normally consists of the two mates—the like-appearing chromosomes that came from father and mother respectively. Then these pairs draw apart; 24 of the chromosomes go to one side of the cell, 24 to the other. But all of the chromosomes of maternal origin, for instance, do not go together; the chromosomes are shuffled so

that in the group of 24 at one side of the cell there may be one of maternal, 23 of paternal origin; or vice versa; or half from each parent; or any other combination in between.

The cell next pinches in two, in the middle, making two cells, each of which contains only 24 chromosomes; but these chromosomes are a full set, so to speak, —one of each original pair.

The sperm cell then goes into the union with only 24 chromosomes. It fuses with an egg cell which has reduced in the same way and likewise contains only 24 chromosomes. Each chromosome finds one of its own size and shape to mate with; the union produces a fertilized cell with $24+24=48$ or the normal number for the human species; so the baby starts off at par.

The baby is produced from this single fertilized cell, merely by indefinitely repeated divisions of the cell. It divides to form two; these each divide to form four, and so on until enough have been produced to make a complete human being.

What happens when the cell thus divides during growth? Some way must be found of dividing the chromosomes fairly between the two daughter cells that result from the splitting; otherwise everything would be upset.

If a cautious father had a bag of bananas to divide between two children exigent of justice, how would he go about it to avoid any possible charge of unfairness? He might give each one of them half the bananas; but as these are of different sizes he could not attain a fair division in that way. He might cut the bag in two; but this again would probably leave more bananas in one half than in the other.

There is just one way that would prevent any possible complaint; and this is the way that nature has adopted. If each of the individual bananas were very carefully split in halves, lengthwise, and a half of each banana given to each child, neither could charge favoritism.

So when a body cell is about to divide in the process of growth, each of the chromosomes it contains splits longitudinally. Half then goes into each of the daughter cells as they separate; and the

chromosome constitution of the cells is therefore maintained unaltered indefinitely, if the machinery works with its accustomed precision. (Occasionally an accident may happen during this process, giving rise to important results. A discussion of this is reserved for Chapter XXVI.)

The fact must be continually borne in mind, then, that there are two entirely different types of cell division, for two different purposes.

1. The reduction division is so called because its effect is to *reduce* the number of chromosomes. It (*a*) does not occur in all cells, but only in germ cells; (*b*) occurs only once in the lifetime of a cell; (*c*) reduces the number of chromosomes contained in the cell by half.

2. The equation division is so called because it divides the cell while giving to each half an *equal* amount of chromosome material. It (*a*) occurs in all cells; (*b*) occurs continually; it is the regular way in which a cell divides, and the cell must be dividing continually in growing tissue because that is the way that tissue grows; (*c*) it leaves the number of chromosomes unchanged, by the simple expedient of splitting each chromosome lengthwise, so that each of the daughter cells has a full set of the original chromosomes.

Going back to the reduction division, when the two germ cells (egg and spermatozoön) are preparing to unite, it will be remembered that the 48 original chromosomes are not all different in shape: rather they consist of 24 pairs, so that there are two alike of each kind. Of these pairs, one member came from the father at the start, the other from the mother.

But of the pairs, no two chromosomes are alike in constitution, even though they are alike in shape. Hence the germ-cells with the reduced number of chromosomes will not be alike. Thus if two human germ cells were reducing, one of them might throw out all of its even-numbered chromosomes, the other all its odd numbers. The resultant germ-cells, though each containing the proper 24 chromosomes, and each the product of the same man or woman, would not have a single chromosome in common.

With 48 chromosomes taken 24 at a time, anyone who remembers his high school algebra can calculate the permutations and show that the number of different kinds of germ-cells—no two alike—which can be produced at this reduction division¹ is $2^{24} = 16,777,216$.

Here is one good and sufficient reason why no two human beings, not even two brothers or two sisters, are alike, (excluding the special case of identical twins). Even if they are children of the same parents; even if they are ordinary twins, developing side by side in the uterus and born only half an hour apart; they are yet the products of germ-cells, each of which contains a different set of chromosomes.

Thus, even though the child is the heir of the whole race, he does not resemble the whole race in details.

In the fundamental features he does; for these were established in the germ-plasm hundreds of millions of years back,—long before anything resembling a man appeared on earth. Some of these primitive characters are so tenacious that every baby has to go through them, and outgrow them on his way to be a man.

For instance, while the child is an embryo in his mother's womb, he has at one period gill slits on the sides of his neck, similar to those of a young fish embryo. It is difficult to interpret these as anything except a reminiscence of past history, going back to the almost incredibly remote period when the child's ancestors swam and breathed in the water like fishes.

A little later, the tiny baby has a tail,—not merely a suggestion of one, but one that is longer than his legs,—I almost said, "longer than his hind legs." The tail is absorbed gradually while the legs grow longer, until by the time the fetus is three or four months old the proportions are near those that exist at birth, save in extremely rare cases where the tail persists to adult life (277).

¹ Presumably genes cross over at times from one chromosome to another in man as they have been found to do in other mammals (see Chapter XVII). This makes the real number of possible different kinds of germ cell very much greater than the figure given above.

Since the fetus has no conceivable use for such an evanescent tail, the only credible explanation is that the child is going through the period when his ancestors had long tails.

The ability of the newborn baby to grasp, and even to sustain his whole weight for an instant by his hands, was mentioned in Chapter I. If this ability were necessary or useful to the baby, it ought to endure. The most reasonable explanation seems to be that, like the gill slits, tail, and many other reminiscences, it is merely an echo. When man's ancestors lived in trees, the young at birth had to be able to hold on to their mothers, or they would have died prematurely. This ability has survived in an abridged form up to the present time.

It is a far cry from the days when John Jones' ancestors had tails or gills, to the days when they had Roman or pug noses and auburn or sandy hair, as the case might be. Hence the former potentialities are much more deeply imbedded in the germ-plasm—to use a somewhat violent figure of speech—than are the latter; and it is not surprising that every child inherits the former while only a few children inherit the latter.

The possibility of this is understood in recalling the cell reduction division with its elimination of half of the chromosomes. The tail, one may assume, has been there so long that genes which affect it are in every chromosome; the pug nose is a more recent invention, and its differential genes are in only part of the chromosomes of the race. This is a crude way to picture the facts, merely a figure of speech, but it will serve the present purpose.

If the pug nose is only in certain chromosomes, then whether John Jones get it or not depends (1) on whether it is in any of his particular lines of ancestry, and (2) if it is in his ancestry, on mere chance, as represented in the reduction division of the chromosomes.

The latter qualification helps to explain why a child does not have all the characters of all of his ancestors. Some of them were represented in chromosomes (or parts of chromosomes) that were thrown out of the line before it reached him. A moment's thought

will show that, merely on the doctrine of chances and the random assorting of the chromosomes in the reduction division, some of his ancestors are not represented in John Jones at all, while from others he may get more than a proportional share of traits. Thus if John had sixteen different great-great-grandparents, it is not reasonable to suppose that he gets one-sixteenth of his make-up from each one. Several of them might not be represented in him in the slightest degree, from a biological point of view, although legally they are as good as any others. He may have inherited Great-Grandfather Jones' jewelled snuffbox or second-best bed or apple orchard, but have inherited not a single atom of that worthy's germ-plasm. So the analogy between biological heredity and legal inheritance is likely to be misleading, and must not be pushed too far.

It follows, with much greater force, that some of the 16,000,000 living members of the "William I for Ancestor" Association must be little more closely related to him, genetically, than they are to Buddha or Tutankhamen.

There is no sure way of telling from which of one's ancestors one actually has a biological inheritance; but it is certain that many of the more remote are not represented at all in the living descendant.

This situation is intensified in a number of ways.

In the first place, suppose the parents were first cousins. Then John Jones has only eight different great-grandparents instead of sixteen, and each of them has twice as much chance to be represented in the descendant as he would have had if Mr. and Mrs. Jones were unrelated. This is the effect of consanguineous marriage or inbreeding. In any settled European or American population, one marriage in 100 is likely to be between first cousins, and in groups that intermarry a good deal, as the aristocracy or the Jews, the proportion of cousin marriages may be several times as great. Evidently the lines of ancestry must be knotted together rapidly in this way.

Live-stock breeders, using the same ancestors over and over

again by breeding brother and sister or parent and offspring, easily produce quick results; so that it is more than a figure of speech in many cases to refer to a certain animal as the founder of the breed, whereas there may be a hundred men just as well entitled as Jonathan Edwards or Max Juke to pose as founder of the clan that now does these credit or discredit.

Sewall Wright has called attention to a remarkable illustration. Charles and Robert Colling, two brothers who bred cattle in England in the latter part of the eighteenth century, had a bull, dropped in 1793, whom they named Favourite, in their herd of Shorthorns. As his characteristics were satisfactory to them, they bred him to his own daughters for generation after generation, and other breeders used his descendants in the same way. The result is that about half of the ancestral lines of every living Shorthorn run back to Favourite, and that, measured by statistical methods, any Shorthorn today is more closely related to Favourite, a bull who died more than a century ago, than father and son are ordinarily related.

But, as has already been pointed out, consanguineous marriages (though of remoter degree) are taking place continually: they are not the exception but the rule, although the fact is not known to the bride and groom, simply because their knowledge of their own ancestry is scanty. Who, for instance, knows the names, even, of all the living descendants of each of his 64 ancestors in the sixth generation? If each pair of these ancestors had four children, more than 12,000 of their descendants may now be living. How are two of these, introduced to each other by strangers, to know that they are related, and that their marriage is the marriage of kin?

The result of these more or less remote consanguineous marriages is that certain ancestors appear much more frequently than others in anyone's pedigree. They are the most likely to have possessed traits similar to those of the living descendant; or to turn the picture around, the living man is most likely to possess the same traits that were possessed by a man (or woman) who appears a number of different times in his ancestry.

In addition to this, there is the tendency for people to marry those like themselves. To take an extreme illustration, a white man tends to marry a white woman rather than a black or yellow woman; hence white children are more likely to have white traits than black or yellow traits. But the tendency is much more detailed. Healthy people tend to marry each other and sickly people tend to marry each other. Tall men tend to select wives who are at least taller than the average; the short are most likely to marry among themselves; and so on.

The result of this is the same as the result of cousin marriages, that is, to bring like traits together in the germ-plasm and send them along together.

Finally, people of the same social class, occupation, or interests tend to intermarry. This prevents the even spread of lines of ancestry throughout the population, and tends to arrange them in layers. These layers are connected together by numerous lines of ancestry running from one to another; nevertheless they are distinct, and are said to grow more and more widely separated from each other all the time (409).

The result of all such influences is to get various kinds of germ-plasm separated out, and to keep them so.

Those who, for emotional reasons, believe in the literal equality of all men, often point to the fact that the child is heir of the whole race as evidence that all children must be born alike, and that any child with proper education can be made just like any other child,—the best or the worst of his kind, depending merely on the skill of the pedagogue.

Such an idea reflects a gross ignorance of the elementary facts of heredity.

So far as the fundamental traits go, it is true that every child possesses the possibility, if not the certainty, of developing them. Broadly speaking, every child is born with the possibility of having hair on his head.

But whether it shall be red, white, or black hair is a different question, the answer to which depends not on his remote ancestors

who lived in the trees, but on his more recent ancestors who lived in Scotland, or Finland, or Bechuanaland, as the case might be.

It is not far wrong to say that the fundamental resemblances among men go back to the germ-plasm of the remote ancestry, which all share alike; the differences among men are mostly due to the germ-plasm of the more recent ancestry, which no two share alike—not even full brothers or full sisters, for the reasons pointed out in the discussion of the cell reduction division above.

And it is the differences in men that account for their differences in achievement.

If a man were breeding live-stock, he would never dream of following the equalitarian doctrine. If he wanted to produce a champion trotter, he would not breed an old plow mare to a broken-down Shetland pony stallion, on the theory that both were heirs to the whole horse ancestry. If he wanted to produce superior homing pigeons, he would not cross a pouter with a fantail, on the assumption that proper education would make any squab a homer, because they were all pigeons.

What holds true of the influence of immediate ancestry in live-stock holds equally true in man.

CHAPTER III

BROTHERS AND SISTERS

"Is it a boy or a girl?"

The first question asked about any new baby points to the greatest difference that can exist between two normal human beings; for the two sexes differ in detail in almost every conceivable way (301). An examination of the manner in which such marked differentiation occurs in two children of the same parents is a good way to approach more closely the mechanism of heredity.

When the immature germ-cells of a man and a woman, respectively, are examined under a microscope, a regular and marked difference is found. Each contains 48 chromosomes (24 pairs), and in 23 of these pairs the mates resemble each other so closely as to be indistinguishable. The remaining pair is different in the two sexes, hence it is customary to speak of these two as the sex chromosomes.

In the female the sex chromosomes are two short rods which are customarily called the X chromosomes. In the male one of these rods is missing and its place is taken by a smaller chromosome, round or egg-shaped, which is designated as the Y chromosome. The formula of the female in this respect is therefore XX, of the male XY; and this is the fundamental, germinal difference between the two sexes, from which all other differences seem to be derived.

When this complete number of chromosomes is reduced by one-half in the mature germ cell, prior to sexual conjugation, it was pointed out in the preceding chapter that the pairs of chromosomes separate. When a female cell divides, each daughter cell is certain to contain an X, since the mother contained two Xs. There is no alternative, (unless the machinery is out of order, as may sometimes happen).

In the division of the male cell, however, containing the pair XY,

it is equally clear that half of the resulting cells will contain X, the other half Y.

Now when an egg comes from the ovary down into the Fallopian tube to be fertilized, it can have only one constitution, namely, X plus the other 23 chromosomes.



FIG. 5. THE SEX CHROMOSOMES

In this cell, taken from the testicle of a Negro, the X and Y chromosomes characteristic of the male sex are separating early, while the other 46 chromosomes are still clumped together in a black mass in the middle of the cell. What is called a chromosome is perhaps simply the effect produced in the surrounding protoplasm by the genes; and at different stages these produce different effects, so that one day a chromosome will be a thin, long thread, scarcely visible, the next day it will appear condensed into a short, blunt rod. Illustration from Theophilus S. Painter.

It finds awaiting it (in favorable circumstances) a whole host of spermatozoa; but these are of two kinds. One-half of them consists of X plus the other 23; the other half consists of Y plus the other 23.

If the mating of the two germ cells is at random, it is an equal chance whether the X egg encounters an X sperm cell or a Y sperm

cell. If the former, the fusion results in XX or the production of a female. If the latter, the consequence is XY or the production of a male.

The conception of a boy or a girl is therefore a matter of chance, since it is impossible to influence the germ cells as they are mating in the mother's Fallopian tube.

Moreover, the production of a boy or girl depends on the father, since he produces germ cells of two kinds while the mother produces only the one type.

This simple chance mating, which involves the same principle as tossing two coins for heads or tails, ordinarily settles once for all the sex of the resulting offspring; and it accounts easily for the fact that there are just about equal numbers of boys and girls born in the world.

As a fact, there are rather more boys born alive: approximately 105:100. The causes of this are complicated, depending on the fact that the dice are loaded—that the smaller and lighter Y spermatozoön is more likely to reach the egg first. As I have gone into this subject rather fully in a recent book on *Problems of Human Reproduction*, I shall not traverse the same ground here. The essential fact for the present purpose is that, at each mating, the sex of the child is determined by chance, either alternative being equally possible.

There is of course no relation between the chance at one mating and the chance at the next, any more than throwing heads at one toss of the penny influences the results of the second toss. Many parents think otherwise, thereby becoming victims of what is perhaps the most widespread of all statistical fallacies, among both parents and gamblers.

When a number of boys is born in succession, it is often supposed that the next child is likely to be a girl. Such a supposition ignores the independence of the events in the series.

If heads are thrown 10 times, almost anyone would prefer to bet that the next throw will be tails. The wager would be ill-founded. If the throws were stopped when heads had appeared 10 times,

and only resumed a week or a year later, few would fail to recognize that the probability of heads or tails at the next toss was even.

If one were betting on the series, one would bet that heads would not appear 10 times in succession, unless he were dealing with such coins as Cox and Box used. But if one were betting on the individual throw, they are all the same. The mistake is due to the fact that people tend to look back to the origin of a chain of events, when this is not too remote. But when, as in this case, each link in the chain is separate, the origin has no significance.

Thus if young parents announced their intention of having five children, any sporting relative would be justified in laying odds that not all five would be boys; and he would win much oftener than he would lose (31 times out of 32, to be nearly exact, since I am here assuming for simplicity that equal numbers of boys and girls are born, whereas the real ratio is about 105:100). In any given birth, the chance that the child will be a boy is approximately $1/2$. The chance that two in succession will be boys is therefore $1/2 \times 1/2$ or $1/4$, for three $1/8$, for four $1/16$, and for five boys in a row $1/32$.

There is an account of an Irishman in the eighteenth century who by three wives had 40 boys in succession. Assuming for the sake of argument that the account is true, it would occur so rarely that one questions whether it ever happened again in the history of the world. The chance of it is only $1/2$.⁴⁰ But when the doctor was called to deliver mother No. 3 of child No. 40, he was just as likely to deliver another boy as to usher into the world the long-desired little girl. The chances on this particular event were even, though the chances against the *series* of events (40 boys in succession) were immense.

The eradication of this statistical fallacy would save the disappointment of many parents and the bankruptcy of many gamblers, but it is so deeply rooted that it will probably not disappear for a long time.

Since the X or female-determining chromosome is larger than the Y or male-determining chromosome, one might suppose that the

real factor which determines the sex of the resulting embryo is the amount of chromosome material that goes into the fertilized cell. A cell with the constitution XX contains a larger amount and is female; a cell with the constitution XY contains a smaller amount and is male.

Some very nice experimental breeding of lower animals has made it appear probable that this is, in fact, the true explanation. By the presence of a larger or a smaller amount of chromosome material of a particular kind, the fertilized cell is started off at a certain level of development and given an initial impulse which carries it on for three or four months, at least. During this time, the reproductive glands are formed in the embryo. These start much alike in each sex—in fact, one can not tell with certainty what sex a very young embryo will turn out to be. If the cell is at the higher level of development, these glands become testicles, if at the lower level they become ovaries; and as soon as they form, they begin to secrete the hormones which continue to guide the development of the embryo into the complete male or female.

All of this time there is of course a constant and complicated interaction of many kinds going on in the development, and many different factors contribute toward the completion of sex. But two facts stand out clearly: first, that the cell receives its initial impulse toward one sex or the other, by the amount of special chromosome material that goes into it, which produces a certain level of metabolism; and secondly, that this impulse is picked up and carried on through development of the characteristic reproductive organs (and other internal glands) of the one sex or the other.

Evidently there are many possibilities of deviation or disaster in this complicated process of development.

1. There may be differences in both the amount and the quality of chromosome material, carried into the fertilized egg cell. Of two such cells starting development side by side, one might get a vigorous shove that would land it at a high level and end in the production of a two-fisted he-man with hair on his chest; the other

might receive only a weak and ineffectual push that would start in on a level barely high enough to avoid the production of an out-and-out female, and end in the production of an effeminate, more or less sexless boy—a sissy in youth and a granny in maturity.

2. The development might start off at the proper level and be delayed at the critical period when the reproductive glands are being formed. This again would change the end result. The most likely cause would be the presence of other inherited traits that are developing at the same time, and for some reason are not compatible with the normal development of sexuality. The two processes of development interfere with each other, with the result that both are hindered.

3. A normal child may be born, and through physical or mental disturbances in childhood his full sexual development may be interfered with.

4. Finally, any disturbance in the functions of the internal glands during puberty, at the time when the sexual system is being perfected, may result in a similar abnormality.

It is worth while to go into this normal development of sex in some detail, because it illustrates what occurs with other characteristics. The germ-cell starts with its own, highly complicated constitution; the adult ends with his own, highly complicated constitution. The latter has been produced from the former, but there is no simple one-to-one relation between the two.

It is naïve to suppose that there is in the germ-cell some little speck that develops into maleness, or blue eyes, or bad temper, as the case may be. One must rather think of the fertilized egg cell as an incredibly complicated living thing which has within itself the power of growth and development and change to such an extent that a particle of protoplasm not as big as a pinhead develops, by its own internal mechanism and with the addition from the outside of nothing but food and water, into a man six feet tall.

Complicated as my description may seem, it is simplicity itself compared with the indescribable complication of the endless system of chemical and physical reactions that go on in this egg

while it is developing into a man. The potentialities of all sorts of inherited traits are developing side by side; each one affects every other one; the final result represents the combined effort of them all, and yet through this seeming chaos of products and effects there run, in some way, persistent patterns of such nicety that the boy is born with a notch in the lobe of his right ear, and at the age of 30 develops a lock of white hair on the left side of his forehead, just as his father and grandfather did before him.

With the inheritance of sex are bound up other characteristics: so it may be said that the trait of sex affects, in development, almost every other trait in the body. The differences in physical proportions, according as the child is a boy or a girl, are conspicuous enough; the mental differences are no less marked, although they predominate in the feelings rather than in the more intellectual capacities.

The development of femaleness seems to limit the development of intellectual traits. Women have never in history attained as great eminence in any intellectual pursuit as have men, though they may surpass in other mental traits. Those who wish to live at peace with the world may take refuge in the formula that the male is the more intellectual, the female the more intelligent, of the sexes.

On the other hand, the development of maleness carries with it less physical resistance to many adverse conditions. More boy babies die at every age, before and after birth.

Speaking broadly, one may say that the female sex is the weaker intellectually, the male, in one sense, the weaker physically.

Most other differences among individuals certainly do not affect as many other traits as markedly as does the difference of sex; yet the distinction is merely one of amount. I shall have occasion to point out many times in the following pages that every difference in the germ-plasm produces numerous differences in the body. It is equally true that every difference in the body is the product not of one but of many differences in the germ-plasm, working in accord with each other.

The inheritance of sex thus forms a good introduction to the inheritance of other traits, precisely because it is an extreme case and thus easily recognized. It is typical of all other inheritance in two respects that must be particularly borne in mind:

1. Sex is due to a definite difference in the chromosomes; and since the chromosomes are sorted out and distributed at random in the germ-cells, this difference is also passed out at random, exactly as it would be if it followed the results of throwing dice or tossing pennies.

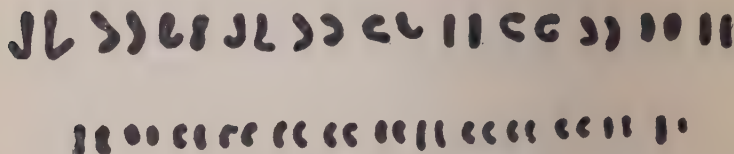


FIG. 6. THE 24 PAIRS OF CHROMOSOMES

In this illustration (from Dr. Painter) the 48 chromosomes from a cell in the testicle of a Negro have been arranged to show the 24 pairs. At the right hand end of the lower line are the X and Y chromosomes. When the cell divides prior to fertilization of an egg, these pairs separate, one of each pair going into each side of the cell; the cell then pinches in two, leaving two cells each with the reduced number (24), and each having one chromosome of each pair. It unites with an egg-cell that has reduced similarly, so the union of the two cells, each with 24 chromosomes, restores the normal number (48) for the species.

2. The production of one sex or the other is a marked result of this difference in the chromosomes. But all sorts of other effects are also produced by the same difference.

3. There is a third fact of great importance that can be inferred from a study of this situation. In every human male body, the X and Y chromosomes lie side by side in the germ cells for many years—usually for a quarter of a century or more. Then the germ cells come into activity; they divide, the X going into one and the Y into another spermatozoön prior to conjugation. Yet it is clear from the results that these two chromosomes, lying side by side for a generation, have not influenced each other in any way. They have not contaminated each other, so to speak. The male-determining Y chromosome is no less masculine because of its long contubernation with the female-determining X; and vice versa.



FIG. 7. THE MENDEL MEMORIAL AT BRÜNN

Opposite the little garden where he worked happily among his flowers and his bees, friends of science have erected this monument to the priest of humble origin, who never succeeded in passing the examinations for a high school teachers' certificate, but who became abbot of one of the wealthiest monasteries in old Austria-Hungary and made the fundamental discovery in the modern science of genetics. Illustration from Hugo Iltis' *Gregor Johann Mendel*, through the courtesy of the *Journal of Heredity*.

The first and third of the facts just mentioned—that is, the independent segregation and the non-contamination of the physical bases of inheritance—now seem obvious enough, but half a century ago they would have been considered revolutionary by biologists. In fact, they were so revolutionary that when they were discovered by an Austrian monk, no one paid any attention to them.

This monk was Johann (afterward given the name of Gregor) Mendel (182): born July 22, 1822, died January 6, 1884. He carried on many kinds of experiments in introducing and breeding plants; among others the hybridization during many years of distinct varieties of peas. It was from these that he worked out the principles of heredity, particularly Nos. 1 and 3 above, which often go under the name of Mendel's Laws. He made these public in 1865, but they were not widely circulated and the biologists who saw them were not ready for them, so they lay unnoticed until 1900 when three other botanists, having independently rediscovered the facts on which they were based, also turned up the priest's forgotten publication.

The facts were not new—they had long been available for anyone, and many students had gotten a glimpse, at least, of what Gregor Mendel saw plainly. But most of these students, trying to look at a whole plant or animal at once, had become confused by what they observed. The important differences between the Mendelian experiments and all those which preceded—the differences that gives the monk his title to fame—now seem simple.

1. He focussed his attention not on a whole plant, but on a single characteristic,—one character at a time.

2. He crossed two individuals which differed in having different amounts of this particular character: for instance, tall with short, and smooth with wrinkled skin.

3. He took great pains to count up the exact numbers of each kind that resulted from his crosses, and thus discovered what no one else had realized to be important, namely, that the proportions of the two kinds were constant.

4. He followed these characters through several generations,

instead of stopping with the first generation of offspring as most of his predecessors had done and as too many of his successors still do.

Simple as all this seems, it was such a long step in advance, in the understanding of heredity, that the entire modern knowledge of the subject is sometimes called, in his honor, "Mendelian heredity." I myself shall occasionally speak of a trait as a simple Mendelian unit, meaning that it behaves as did the selected characters of the monk's peas: that it is a simple case apparently free from complications.

But it is inevitable that the progress made since his time has gone far beyond anything he could have dreamed, so that the simple laws which his insight recognized in his garden are only a small, even though a fundamental, part of the present knowledge of heredity. To call this knowledge Mendelism is not much more accurate than to call modern astronomy Galileism.

CHAPTER IV

THE SKIN

The skin of mankind was presumably dark brown, in the first place, like that of most of the apes and monkeys. The lighter shades that now characterize many races must represent a loss of some of the original possibilities of pigment production.

The bleached Nordic, clothed and living indoors, can not be compared fairly with his animal kindred, for his skin contains much greater possibilities than are often shown. This is realized most easily in the desert or at the beach, where many youths take pride in acquiring a coat of tan and become darker than Arabs. But in general it is true that the darker races have the greatest power of pigment production. Even a Negro will tan markedly during a summer in the cotton fields and bleach out noticeably in the winter.

Loss of some of the inherited capacity for pigmentation must have occurred many times in many different regions, for it is still occurring. In Europe true albinos are said to be one in from 10,000 to 20,000 of the population. There are records from almost every savage tribe ever known, of the appearance of albinos, who form merely the extremes in the range of lighter colors; and albinos are also known among many wild animals. Occasionally the trait spreads enough to advertise a new white race, as the so-called white Indians of Panama among whom, as a result of consanguineous marriages, albinism is 75 times as common as it is in the United States, in spite of the fact that the albinos (or more correctly, partial albinos) are not allowed to marry (150).

On the whole, however, the lighter shades of skin have tended to become concentrated in the northwestern part of Europe, where the cool, foggy climate did not penalize their possessors. Thence they have spread by emigration and have been enhanced by sexual selection. Light skin came to be looked upon as a mark of social

superiority, partly because in some countries a darker population was ruled by Nordic conquerors; and to be preferred in mating. An extension of this tendency is found among Negroes in the United States at the present time, the lighter mulattoes being at a premium in marriage.

The inheritance of skin color can be studied conveniently in matings of Negro and white. The mulatto offspring are about intermediate between the two parents, but in the following generations this intermediate color tends to break up or segregate into lighter and darker shades, thus pointing to the existence of several different genes that contributed to the original darker color.

In general the offspring, among whites, will tend toward the darker rather than the lighter parent, but they will not be darker than the darker parent. There may be occasional exceptions to this rule among mulattoes, but striking deviations can be explained away. Thus there are several instances on record where a Negress has given birth to twins, one black and the other light in color. There is every reason to believe that in this case the twins were by different fathers, Negro and white respectively. The old superstition that a "pass for white" mulatto woman married to a white man may by reason of "atavism" give birth to a mulatto child, has no foundation,¹ although it goes back at least as far as Plutarch. If such an incident has occurred, the real father was not the woman's white husband.

Typical albinos are characterized by an almost total lack of

¹ This spoils the point of various magazine stories; but many biological myths which have been dragged into fiction have about as much pretension to science as the weather forecasts in a patent medicine almanac. Gertrude Atherton, in *Black Oxen*, draws a picture of gland rejuvenation that even Ponce de Leon would have received with skepticism. Nathaniel Hawthorne built a novel around the notion of maternal impressions, sometimes called prenatal culture or "Marking," which is nothing but pure superstition (283). Rudyard Kipling in one of his tales of India, *At the End of the Passage*, uses the ancient notion that a dying man's eyes retain a photographic record of the last thing he looked at. It is not necessary to suppose, however, that Mr. Kipling believed this himself.

pigment in the body,—not merely in skin and hair, but also in the eyes, which are gray but look pink in the right light because the blood vessels in them are uncovered. This wide deviation from the normal seems to be due, in many cases, to a single difference in some chromosome.

The chromosomes are not alike throughout their length, like a shingle mail or a match stick. They are composed of distinct units, like beads on a thread. Perhaps they may be better likened to a string of magnetized steel balls, held together merely by mutual attraction.

The units which make up this string, which are the ultimate physical bases of heredity, are known as genes—they are the basis of the genealogy, one may remember. All features of the mind or body develop through the concurrent action of all the genes, of which there are probably several hundred in each chromosome; but there are some well-marked peculiarities—few enough in comparison with everything that makes up the individual, but surprisingly numerous if counted separately—in which the activity or inactivity of a single gene is decisive. The characteristic—albinism, in this case—may then be said with a reasonable regard for truth to be due to a single gene; and if this gene is lacking in the germ-cell, the individual will not be an albino.

This statement must be qualified immediately to say that it is not always the same gene that causes albinism. If the albinism is among kin, it is probable that the same gene is found in all of them, because it came to all of them from a common albino ancestor. But an albino from Siam and an albino from Panama would probably have different genes for this peculiarity, and it might well happen, if they married, that these genes would not be complementary to each other, and that the ancestral skin color would reappear in their children. Abundant instances of this sort could be described from experimental breeding of other animals, and there is a famous case, not the same but at least illustrative, from Surinam. Here a Dutch planter married an albino Negress and had seven children, all typical mulattoes,

much darker than either the white (blond) father or the white (albino) mother.

It is convenient, and probably not very inaccurate, to think of a gene as a little packet of chemicals. It can be handed along in cell division; it can even be and frequently is split, or synthesizes a duplicate, and each of the pair then has all the potency of the original prescription, for internal use only. Under the appropriate conditions, in the development of a baby each of these packets of chemicals starts something going: then the movements and chemical changes influence and alter each other, in bewildering complexity. But no matter how great the final result, the original cause was a single small packet of chemicals set free in the proper surroundings and given the proper material (the protoplasm of the cell) to work on.

So albinism may conveniently be said to depend on a single gene. If this is present in the germ-cell from both sides of the ancestry so that the infant gets a double dose of it, development starts off like a wagon pulled by a strong team of horses. If it is present from one ancestor only, it is like one horse hitched to a load of hay; it cannot pull the wagon and must wait for its team-mate, meanwhile standing inactive, so far as one can judge. At any rate, the gene is not affected by its sojourn alongside of other genes, even though it may be carried on this way through generations and centuries, until finally it comes into union with a gene of its own kind and produces a most unexpected albino child. One family is recorded in which albinism thus lay dormant for five generations and then reappeared. Because of lack of records, such cases are usually not recognized and the trait, coming to light, is hailed as something entirely new.

Albinism is therefore a good illustration of a simple Mendelian trait.

1. It is due primarily to a single difference in the germ-plasm, i.e., to the action of a single gene.

2. This gene segregates in the posterity of an affected individual, going to a definite proportion of the descendants in accordance with the scheme of the division of the chromosomes.

3. It is not "contaminated" by long association with other genes. The gene existing in Negro stock, for example, may be passed along for a century without coming to expression, and at the end of that time if it meets its mate and produces an albino child, this child will be just as pure albino as was the ancestor, regardless of the generations of black skin which have gone between.

4. It influences not only the trait from which it takes its name, but others—presumably all others. Some of these effects are evident, some are not. Thus the difference in the germ-plasm which causes a child to be albino also causes it, in many cases at least, to be born with nystagmus (see page 58), to have delicate eyes which can not stand exposure to the light, and to possess a deficient sense of smell (see page 44). The albino has a shorter expectation of life, and he has been said to be prone to mental derangement. Certainly albinos of great intellectual eminence would be hard to find in history. John Milton is often charged, by people who do not admire him, with having been an albino, but it is not true. He was merely a light blond. Among the Indians of Panama, albino males were found to be shorter and slighter than their unaffected relatives. In other words, this single change in the chromosomes produces numerous and diverse changes in the adult.

Convenience requires that a gene be given a name, and it is named after some particularly striking change that it produces, or perhaps the first change that was recognized. This is in a way unfortunate, because it has led many who are not familiar with the subject to suppose that there is a given gene which produces a given trait in a child; and this conception is a misleading one which can not fail to cause confusion.

One must rather picture the thousands of genes, all pouring out their chemicals or exerting their influence on the cell which contains them, and in this way starting a bewildering number of reactions. Strictly speaking, every one of these genes doubtless produces an effect upon every other one, and every visible trait is the product of the sum total of all the genes. But since the genes are

different, they will produce different kinds of effects, at different speeds; and one group may be of much more direct importance in producing a certain kind of result than is some other group. The final product represents an equilibrium between an immense number of different kinds of activities in the cell, and any change along the line will result in a change, be it ever so slight, in the end product.

5. It also illustrates another fact which has often been considered a fundamental part of Mendelism—the idea of dominance. The gene for albinism, it is supposed, arose as the result of a change in some single gene affecting the normal pigmentation of the skin. It represented originally a sport or mutation.

Little is known definitely of the way in which one gene can thus be changed into some alternative form, but the fact is unquestionable (see Chapter XXV). The change having taken place, the new gene,—albinism, in this case,—continues indefinitely to be an alternative to the old gene. If the two come together, they are closely enough related so that they can pair; but one of them,—usually the one that represents what may be considered the original or normal condition,—is dominant over the other. The latter, called the recessive, can not be manifested fully if in presence of a dominant alternative. It can only be manifested if mated with another recessive like itself.

To get a mechanical idea of the process, one may suppose that the genes differ from each other in potency. One dose of the dominant produces sufficient effect to reach the limit of development possible (a limit that is determined by the effects of other genes present); whereas it takes two doses of the less powerful recessive gene to produce a comparable effect. This is a crude enough picture, but perhaps helps to make the concept of dominance a little less vague and mystical than it sometimes seems to be.

Every albino child must therefore have received a recessive gene from each side of his ancestry; whence there is extra liability that the trait (or any other abnormality which is likewise dependent on a pair of recessive genes) will appear in the marriages

of cousins. But since, as was pointed out in Chapter II, persons of the same race are all cousins in more or less remote degree, the likelihood that a recessive gene will find its mate is proportionate to the amount of intermarriage that has existed in the ancestry.

This is the reason why cousin marriages have often been looked upon with suspicion. They give recessive genes a chance to show themselves, and if, as may often happen, these genes are bad ones, the offspring is penalized. Isolated communities in which there is much marriage among relatives are quite likely to show an abundance of defects due to recessive genes. Mental deficiency may be almost chronic in a small mountain valley which has little immigration. Among the Jews of Berlin, deafness is four or five times as frequent as among the Gentiles.

On the other hand, many great families owe at least a part of their greatness to cousin marriages in strong stock (299).

Mendel himself apparently thought that dominance was a regular part of inheritance, and it used to be listed as one of "Mendel's Laws." But further investigation has shown that it is the exception rather than the rule. It exists in many conspicuous minor traits such as skin or eye color and in striking abnormalities due to a single gene, and therefore its prevalence and importance have been overestimated. Since it is not a part of the mechanism of heredity, but merely a phenomenon of development, it is natural to expect fluctuations in it.

Theoretically, dominance is never complete: no two genes ever act together without some reciprocal influence. This does not alter the fact that they will go on to the next generation quite unchanged and showing no traces of this interaction. It simply means that while they are influencing development together, there is a continual give-and-take between them.

Probably a great majority of genes show little or no dominance—at least not enough to be discovered. The team works harmoniously. Probably in cases where dominance appears to be complete, a thorough study would show that the recessive is actually producing an effect of many kinds, even though it seems to be masked wholly by its dominant mate.

Nevertheless, in some striking cases dominance is complete enough to be conspicuous. Thus, to go back again to the illustration I have been using, the Negro family which carries a single recessive gene for albinism appears just as black as its neighbors. If the gene is exercising any influence, it is either of a microscopical nature that has not yet been detected; or else it is in connection with some other trait than skin color.

(Among the "white Indians" of Panama, those carrying the recessive gene are said to be a little lighter in color than those who lack it. If the observation is correct, it may be that a number of different grades of the same gene are involved here.)

It is a matter of common observation that a fair skin tends to go with light colored eyes and hair. In most people these three features which together with the drug-store make up the complexion agree more or less. There are many exceptions such as the blue-eyed, black-haired Irish, but they are at once recognized as exceptional, and it is their rarity which has led them to be considered piquant. There is no question but that separate genes govern directly the inheritance of color in these three features, but it has also been shown (410) that there is a physiological relation between them. A variation that tends to dilute one has some tendency to dilute the others also. In many countries it has been noted that women are prevailingly darker than men, even though they spend more of their time indoors, sheltered from the sun. This is probably associated with some glandular difference, as of the supra-renal capsules, more active in the male sex and tending to destroy the ancestral pigment. The activity of the female thyroid has also been supposed to play a part.

Among South African Negroes it is said to be the male who is the darker, and the same situation is said to exist among Negroes in the United States (159). When 380 men were asked, "Who, of your parents, is the lighter?," 50 (13 per cent) gave their parents as of the same color, 115 (29 per cent) said their fathers were lighter, and 215 (58 per cent) their mothers. This scanty evidence is "explained" by the fact that dark men prefer to marry the highly-

prized lighter women—the “high yellows” and “pinks.” But whom, then, do the lighter men marry, if not the darker women? Hence the suggested explanation has no validity. It may be that in the United States, as in South Africa, the Negress is somewhat lighter in color by constitution; this is reinforced by the bleaching effect of indoor life, and the use of cosmetics.

Some of the minor variations in the skin that are passed along from generation to generation in particular families are striking illustrations of the nature of inheritance. One family has been described (72) in which a small but definite dent in the forehead is handed on from parent to offspring as a dominant trait. In another, a pit in the earlobe recurs in the same way (184). It looks slightly like the kind of mark that might be left if the ear were pierced for a ring, and of course it was easy for the family to find an ancestress who wore ear-rings, and to suppose that this was the origin of it, though it is scarcely conceivable, in the light of what has been said about the germ-plasm in preceding chapters, that such an effect could occur. How is a hole in the ear to transform itself into some sort of a chemical compound, dissolve itself in the blood, move down to the ovary, enter a certain proportion (not all) of the egg-cells, incorporate itself there in the form of a single gene in a single chromosome; and years later start life all over again in the development of a baby, by producing the long series of minute changes that ended in a reversal of the imaginary process just described and landed it in the open air again, on the lobe of little Eva's right ear?

Analyzed in this way, the idea is as preposterous as it sounds; and in fact not a shred of evidence has ever been produced that a change inflicted on the body can appear in any way in the next generation.

Another family possesses an ear, the lobe of which is slightly split (332). This behaves as an imperfect dominant, appears only in the right ear, and has been charted through four generations. In cattle, a number of pedigrees show the inheritance of a notch in the ear. The effect differs slightly in each herd, so independent

mutations are probably concerned. The same doubtless holds good of the human ear; the effect of a mutation may be great, producing a notch, or small, producing a mere dent or pit. In one family (196) it appears in the upper edge of the ear instead of the lower.

A marked dimple in the chin is not a rare characteristic. In one instance (398) it has reappeared regularly as a simple dominant. It has been thought to be the slightest grade of a tendency toward a cleavage in the median line of the face, which may also be represented by a gap between the middle upper teeth, or a furrow in the nose (232).

The coccygeal dimple at the base of the spine is likewise common; it is supposed to have some connection with the tail that the fetus sports in its early months of life. But there are great irregularities in the size of this dimple; sometimes it is deep and, owing to the growth of hairs in it, becomes a source of irritation,—a fistula, in fact, to be removed by the surgeon's knife.

In another instance a family possesses a skin which forms blood blisters at even the slightest blow. This peculiarity has appeared in three generations, chiefly in women, only one boy being affected.

A catalog of abnormalities of this sort could be extended indefinitely. These traits are of importance from a theoretical point of view, because they show the great precision with which inheritance is carried on. Think of the minuteness of a process which regularly, in a definite proportion of the members of each generation, after the interaction in development of an immense number of different genes, results in a tiny dent in the skin, always in the same part of the body!

Such peculiarities form the bulk of the cases which show marked dominance or recessiveness, and which appear to depend primarily on the action of a single gene. They are simple. More important and fundamental features of the body commonly do not show marked dominance, and depend on the concurrent action of many genes. They are compound.

The minute, simple peculiarities, whose inheritance is so clear

and striking, also form the greater part of the material contained in many books on heredity. As they are of no practical importance to the ordinary parent, I shall largely ignore them in this volume. Insistence on them is particularly undesirable because it gives a wholly misleading picture of the simplicity of heredity.

The inheritance of the important features of the body: of size, strength, health, intelligence, talent, and so on; is made up of similar elements, acting in the same way. But it is not simple.

The sweat glands show peculiarities of size, nature, and distribution that have become differentiated in the several races during evolution.

There are at least two quite distinct kinds of glands in the skin: the ordinary sweat glands, and a larger sort which secrete fat, contain iron, and are found associated with the body hairs. The latter sort are three times as common among Negroes as among whites, and twice as common among women as among men (176). The abundance of these glands, especially in the arm-pit, is on the one hand an explanation of the prevalence of dress shields among women; on the other hand an explanation of the odor of Negroes as contrasted with that of the white race. A sensitive nose would notice that white women give off a different odor from white men, even without the perfumer's assistance. Experiments with police dogs have shown that the fatty acids of the armpit identify an individual more quickly than anything else.

The Mongolian has fewer sweat glands in the armpit than does the European; hence he, it is said, finds the odor of the European objectionable, just as the latter does that of the Negro. Many savage races have complained that the white man smells "sickish sweet;" and this characteristic, I might add parenthetically, extends to his flesh which gourmands (now mostly extinct) state to have the flavor of pig, but sweeter.

Idiots smell different from normal people, and their odor is objectionable to those who come in close contact with it for the first time. Probably differences in the activities of all the internal glands as well as the small ones on the skin play a part in this

difference of odors,—which few civilized people recognize, because the sense of smell is allowed to atrophy from infancy, and is vitiated by tobacco and highly-seasoned food. With evolution, man's nose gets bigger and his use of it smaller.

The dark-skinned races have the most acute sense of smell. The olfactory organ consists of a little patch, about a square inch in size, situated in the deeply-seated parts of the nose and covered with olfactory cells—rod-shaped bodies ending in an enlargement on which is a cluster of fine hairs. At the other end of the cell is a nerve fiber which, joining with others, forms the olfactory nerve that carries sensations to the brain to be interpreted in terms of smell. Among these olfactory cells are lying certain pigment cells which also play an important part, in some way, in the discrimination of odors. The albino lacks them; the brown man has more than the white; and among whites the sense of smell becomes more acute with age, because there is more pigment in the body of an old than a young person. There are, however, families apparently normal in every other respect, who have an inherited lack of the sense of smell (134), just as other families inherit a lack of sight or hearing.

Dark-skinned races in the tropics have also been found to have many more of the ordinary glands of perspiration than do the whites. This adapts them to their climate, by cooling the body, and suggests that if the white-skinned northerner flourishes in hot countries, he was not intended to do so by nature.

Of the minor anomalies of pigmentation, freckles, moles, and birth-marks are all inherited to some extent. Freckles go particularly with light skin and red hair, as everyone knows; a dark skin may conceal them, even if they have been inherited. The concealment of one inherited trait by another, in this way, is common enough, and always has to be taken into account in the study of heredity.

Birth-marks, due to excessive building of blood vessels at a given point in the skin, may be found on any part of the body; the commonest is the one in the nape of the neck, the presence of which is sometimes ignored even by a child's parents, if the hair conceals it.

In one French family there is a record of moles, usually at the same points on the body, since the fifteenth century (7); an American family shows a similar history through five generations (99).

The various types of birth-marks and moles seem to be inherited quite independently of each other; the presence of one kind does not increase the liability to the other. In one-egg twins freckles and moles have been found, with surprising frequency, to occur on the same parts of the body,—good evidence that the location is specified by inheritance. In such ways as this, the study of identical twins in comparison with ordinary twins is a quick and accurate method of analyzing inherited differences (348).

A harmless but striking variation of skin color is the "Mongolian spot" which sometimes appears at the base of the spine of a newborn babe. It is irregularly rounded, ranging in size from that of a pea up to that of an orange or larger (occasionally several are present) and is some shade of blue in color. Usually it fades out during childhood, so that it is rarely found in adults.

In the yellow races it is almost universal; it is next in frequency among the blacks, then in the brown races, and rarest in the white races. It is usually more abundant in the male sex. In the white race it marks one child in 200 to one in 600, according to different authors, but probably it is commoner than this, being found in 1 per cent of all babies in such different places as Paris and Athens, while in South America it reaches a distribution of 15 per cent or 20 per cent.

Among white peoples it runs in families, but irregularly, and is commonly ascribed to "atavism," and explained as the persistence of some of the Bälz cells which exist all over the monkey's skin but have largely disappeared from the human stock. Its frequency seems to be associated roughly with the amount of pigment in the skin of a race, and it has no other relation than that to the Mongolians (212).

No features of the skin are more familiar than the patterns of the so-called friction skin on the hands and feet (290). These are generally thought of as "finger prints," though the toe-prints are

just as good examples of this kind of art, even if somewhat inaccessible to adult inspection. The pattern of the lines in palm and sole is equally characteristic, as any Gipsy fortune teller will testify.

The finger prints of identical twins are usually more alike than those of ordinary brothers and sisters; those of ordinary brothers and sisters are definitely more alike than those of non-related persons. The general pattern is undoubtedly governed by heredity, although no simple rules have yet been discovered for it. The details, on which the finger-print expert largely relies to sort out the ladies and gentlemen of the Rogues' Gallery, are due more to the stretching of the skin in the course of development, and hence are not identical in any two persons. Nearly a hundred such details are recognized, and Scotland Yard will vouch for identity if it finds 10 or more of them.

CHAPTER V

THE EYES

At birth, most white babies have the familiar porcelain blue eye, though an occasional one with brown-eyed ancestry shows the darker color from the outset. Within the first year, most of those who are going to be brown-eyed in maturity have already developed the pigment, though in a few cases it appears much later than this and may not reach its full intensity until adolescence. In one case, parents had twin girls, identical except that one had blue eyes and the other brown. They triumphantly named the one *Blondinetta* and the other *Brunetta*. But alas, by the age of 15 *Blondie* had developed eyes just as dark as those of her sister!

Further, it may never reach its full intensity, so that a boy who was destined by inheritance to have brown eyes may go through life with blue eyes instead, and yet transmit the brown to his offspring. More striking is the case of persons, like *Colleen Moore*, who have one eye brown and the other blue. Here there has been a partial failure of development, affecting only one side of the body: an inherited peculiarity that affects one or two persons per 1,000, and is more common in some other animals. In other families, a small section only of the iris may be pigmented (22, 23); while tortoiseshell-colored eyes characterize still other families, and behave like a simple dominant.

At equal ages, there are said to be about twice as many dark eyes among sick babies as among well babies (329). It is supposed that the illness, affecting the blood, glands, and tissues, causes a deposit of pigment earlier than would otherwise be the case. In some races, it has been found that brown eyes are distinctly commoner among the women than among the men. If this were the whole story, it would be easy to assume that some of the sex hormones affect the development of pigment. But the picture is

more complicated (404). When the father has brown eyes, the mother blue, half the sons have blue and half have brown, but many more daughters have brown than blue eyes. On the other hand, when the mother has brown eyes, the father blue, there is a marked excess of blue-eyed sons and daughters. It is evident, then, that the difference must be explained in terms of genes, and their behavior suggests that dominant genes located in the sex-chromosome are influencing the results.

In old age, the eye sometimes becomes lighter in color. Brown pigment may fade or disappear. In blue eyes, thickening of the iris tissue takes place, so that the pigment shines through less distinctly and gives the eye a more watery, whitish appearance.

It is sometimes assumed that blue and brown eyes are sharply distinct, being due to the operation either of a single (or double) dominant gene, producing brown, or its duplex alternative producing the recessive blue. This statement does not make a bad first approximation to the facts of inheritance—indeed, most such statements are only first approximations, for as knowledge increases the make-up of simple traits is usually discovered to be more and more complex. In this case, the facts are already seen to be more complicated, and there is no doubt that numerous genes are involved, and that dominance of brown is not complete. The most thorough recent study (39), in which 3,000 persons were studied microscopically, found traces of brown pigment in all blue eyes and concluded that at least five pairs of genes are involved.

Throughout nature, lack of color most frequently acts as recessive to the normal coloration, but there are plenty of cases in which white is dominant, not only among the lower animals, but in man (white spotting of the skin, p. 70, white blaze in hair, p. 69). There is no objection to considering the brown eye dominant over the blue, but since the concept of dominance, to which geneticists now attach little importance, is still a mainstay of the pseudo-scientist in the field of heredity, being applied not only to brown eyes but to everything else from ingrowing toe-nails to genius, it is worth a brief digression.

Dominance may be:

- (1) complete, to all appearances, as normal color contrasted with albinism, or
- (2) almost complete (probably this is usually the case with eye color), or
- (3) incomplete,— a common condition; or
- (4) altogether lacking, possibly the most common situation of all, if the totality of traits in man is considered; or
- (5) variable, depending on the action of other genes which modify its expression— a common situation in man; or
- (6) regularly reversible, as for example when influenced by the sexual constitution (pattern baldness, p. 70, which is dominant in man, recessive in woman); or
- (7) irregularly reversible, due to the influence of either external or internal factors.

There are further complications in almost every one of these cases. Variable, imperfect, or reversible dominance is often invoked to cover a gap in the family history: the proper explanation would be not "imperfect dominance" but "imperfect record." It is also possible, in the case of a trait manifesting itself late in life, that a dominant parent may die before the defect shows in him, having first begotten several dominant children who will live to show it and express surprise that "father didn't have it."

Moreover, dominance is a relative term. A gene may be dominant to one, recessive to another, gene. Thus in the very case which gave rise to this discussion, blue eye color is dominant to red (that is, the absence of pigment that accompanies albinism), but recessive to brown. (There are also families in which the lack of pigment in the eye is a sex-linked recessive.) In other words, the gene is dominant only in relation to some other given gene, and that only in so far as the second gene is accompanied by given modifying genes.

Finally, when it is remembered that entirely different genes may be responsible for the same characteristic in different families, or even, perhaps, in the same family in different generations,

and that this fact will naturally alter the relationship of dominance, it will be recognized that this stand-by of the older literature on heredity is worthy of little trust. For convenience I shall frequently refer, in this book, to a given gene as dominant, but I hope it will be understood that the expression is used only for convenience, and that it must always be understood in a relative, frequently even in a Pickwickian, sense!¹

As the eye is the most complicated of all the sense organs, and as this extremely complicated and finely adjusted mechanism is the result of the interaction of a great number of genes, working together through many months of development, it is easy to see the possibility of slight alterations or deviations which will end by impairing the perfection of the organ. These alterations may be primarily in some other part of the body, the effect on the eye being secondary—in some cases (366) a degeneration of the pigment in the retina seems to be the outcome of a faulty development of the liver.

In ancient times the spread of such defects was kept down by natural selection. The myopic early hunter would starve to death; the near-sighted cave man would be killed by a far-sighted cave tiger, probably at an early age. Nowadays, he survives and hands on his defect to his offspring. It is scarcely possible to avoid the conclusion that eye-defects are destined to become more frequent in each generation, since they no longer impose a fatal handicap. Thus short-sightedness, to continue with the example that was mentioned, seems to be commoner all the time.

This is often assumed to be due to the strain of reading and other near work, but a casual examination of the facts shows that such an explanation does not fit. Careful measurements in many cases have shown that there is a close association between short-sight in parent and short-sight in offspring but little between

¹ The term "prepotency," much used among live-stock breeders, is equally vague but when it means anything definite, refers to an animal that is a pure-bred dominant for a number of important traits, so that it is likely to pass these on to its descendants. Such a situation is favored by inbreeding (284, 288).



FIG. 8. FOUR SQUINTERS IN ONE FAMILY

Mrs. C. S., age 46, had had 14 children, of whom 9 were living at the time of this study (*Journal of the American Medical Association*, May 22, 1926). Her right eye had always turned out. Her three youngest children, shown above, have eyes that turn in. The boy's right eye has been turning in since age 2; the older girl's right eye since age 2; the younger girl's left eye since age 1. Although no history of strabismus could be found on either paternal or maternal side of this family, the tendency is found from careful studies to be inherited. Photograph from Dr. Frank H. Rodin, Stanford University Medical School, San Francisco, Calif.

short-sight in children and the time they spend out of doors or the amount of reading they do (11).

At birth, virtually every baby's eyes, so far as can be judged, are adapted to distant sight, as are those of the wild animals (although the power of accommodation is not gained for some months, and the child a few weeks old can focus only on an object held near his face). By the age of four, some 10 percent of ordinary children probably begin to show signs of short-sightedness, although the amount of near work done up to that time is negligible. The percentage increases year by year until by the time the children have reached maturity at least 15 percent are markedly short-sighted and few of them have perfect eyes. But an eye which remains normal up to the age of 20 rarely becomes short-sighted thereafter.

Evidently myopia is a defect that develops in the course of the growth of the eye, depending not so much on outward conditions as on the inheritance. Many persons abuse their eyes abominably and yet do not become short-sighted; others who can not even read or write, and who have lived outdoors nearly all their lives, become short-sighted at an early age. This is not to say that eye-strain is harmless; but it is not the primary cause of defective vision. It is rather a question of heredity and the defect is inherited in different ways in different families, as usual.

It is sometimes said that males are more subject to short-sightedness than are females. This is likely enough, in line with the general principle that the male is more subject to defects of all kinds (see p. 123). But the conclusion must be made on the basis of careful measurements, not on the wearing of spectacles. Some years ago I counted a thousand persons on the streets of Washington, D. C., and found that one woman in seven wore spectacles, one man in four. But many women who need spectacles refuse to wear them, or wear them only indoors, in order not to spoil their "looks."

If both parents have good vision, the children are not likely to be much bothered, in this connection. If the parents have de-

fective eyes, the children are likely also to have them, and pains should be taken to fit them with glasses early enough to prevent excessive strain.

Far-sightedness is also inherited in some cases, as a dominant; but more frequently it is a mere bodily change, due to the drying out of the tissues in old age, which causes the lens to lose its elasticity and change its curvature. Astigmatism is inheritable, often as a dominant. In occasional instances, a man is short-sighted in one eye, far-sighted in the other. Robert Browning possessed this convenient combination. When he was reading, he would keep one eye closed; if interrupted and obliged to look up, he would open this eye and close the one which he had just been using.

Since the normal proportions of the eye are influenced by a great many factors, it is an interesting question whether they may not be upset by race mixture, in which more or less dissimilar elements unite. Thus in England and Scandinavia, where intermarriages have been mostly between long-headed peoples, short-sightedness is said to be less frequent than in southern Germany where a long-headed race has mingled with a short-headed one. A. Czellitzer found 41.8 percent of short-sightedness in the army volunteers of Bavaria,—a part of the nation in which race mixture has been frequent; and only 24.5 percent in Schleswig-Holstein, where the population is still predominantly long-headed, and there has been relatively little racial inter-breeding (63).

This is exactly the sort of trait that one might expect to show disturbances, if any physical trait is disturbed by racial crossing, and it would be highly desirable to have more far-reaching studies on this point.

Most adult blindness is due to industrial or other accidents. Of that which is congenital, most is due to diseases such as gonorrhea and syphilis. Probably not more than 10 percent or 20 percent of the 100,000 blind persons in the United States owe their affliction to inheritance. There are several inherited conditions, however, which behave in definite ways and result in the partial or complete destruction of vision.

A surprisingly large part in the literature of heredity is played by studies of eye defects (177), and it would be possible to run through a list of perhaps a hundred which are well understood. Such a study (49) greatly extends the theory of inheritance in man, but has little practical value for a parent, since many of these anomalies are extremely rare. In line with my policy throughout this book, I shall therefore ignore these, save for a few of particular importance.

Color blindness may be due to disease, particularly to injury of the optic nerve by alcohol or tobacco. But the largest part of it is inherited. It exists in all grades, from a pronounced color blindness to a mild color weakness; and one eye is normally a little more sensitive to color than is the other. The common tests are not reliable in young children, but after the age of eight are fairly dependable.

It appears from a variety of studies that color blindness in a degree sufficient to be dangerous, (for instance, preventing the recognition of red and green signals) exists in about one girl in a hundred, and in at least three or four boys per hundred. Frequently the subject does not realize it. In many occupations, it is a handicap, even a fatal one. The youthful Douglas Haig would have been thrown out of the British army, because color blind, had not the old Duke of Cambridge suspended the rules for him.

When an inherited trait is found in great preponderance in the male sex, but also occasionally in the female, one suspects at once that it is carried in the male X-chromosome,—that little rod which normally determines the production of a boy rather than a girl baby. Such inheritance is called sex-linked.

If it were found in all males, it would be evident that it was an accompaniment of the whole male mechanism—side-whiskers are an example of this sort of trait, which is called sex-limited, because it can appear in only one sex. It is inherently and necessarily, because physiologically, tied up with maleness. The genes on which it depends can produce an effect only in the presence

of certain secretions of the reproductive system. Thus females may inherit the genes, but no effect will be produced, save in the rare cases when some defect or alteration of the female reproductive system gives rise to secretions resembling those of the male. Again, eunuchs do not have side whiskers, even though

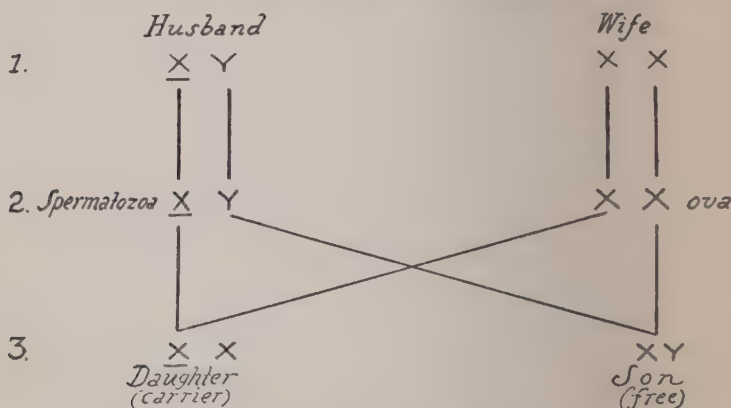


FIG. 9. INHERITANCE OF COLOR BLINDNESS

This diagram shows a simple case of inheritance in which the husband is supposed to be color blind (the gene being carried in his X-chromosome, which is underlined) while the wife is free from it. The husband then produces two kinds of spermatozoa, one of which contains the Y chromosome and hence no color blindness, the other the affected X chromosome. The latter may mate with either of the wife's two X chromosomes; in either case the result will be a daughter who will have a single dose of color blindness and therefore will be a carrier, probably not showing the disability herself but carrying the affected X which she will transmit to her own offspring. The father's Y-chromosome spermatozoa may likewise mate with either X from the mother, but in either case a son free from color-blindness will be born, the gene not being carried in the father's Y or either of the mother's X's.

they may have received the genes, because they too lack the secretions which alone permit the full action of these genes. The sex-limited trait has nothing to do with the sex-chromosomes; its genes may be in any chromosome.

The sex-linked trait, such as color-blindness, has no necessary

and physiological connection with maleness, on the other hand; the association is merely an accidental one, so to speak. The defect is due to alteration of a gene; it merely happened that the gene in which this alteration or mutation took place was in the

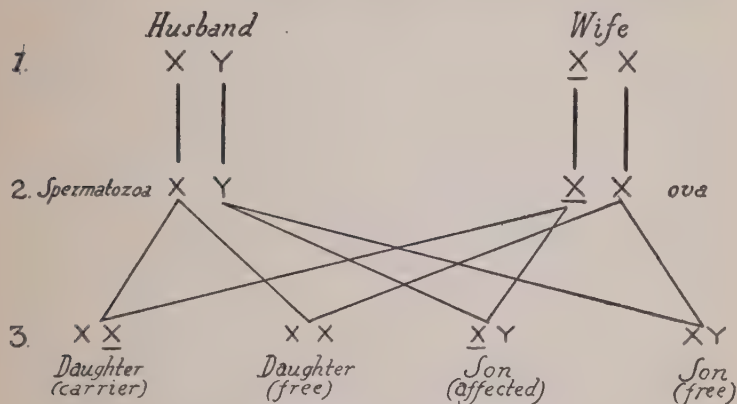


FIG. 10. INHERITANCE OF COLOR BLINDNESS

In this diagram the husband is supposed to be normal, and married to a wife who is also normal in appearance, but a carrier of the gene for color blindness, which is shown in one of her X-chromosomes (underlined). She then produces two kinds of egg cells, one of which contains the affected X, the other the normal X. Four different kinds of children may be produced from this mating, as shown in the third line of the diagram, depending on the random mating of the chromosomes. In a small family, not all of these types are likely to appear, and it might even happen, by chance, that all of the children would belong to the same type—for instance, there might be three daughters, all of them free from the affected X. But in a large population the average results of matings of this sort would be in approximately the proportions shown in the diagram.

X-chromosome; but the result is striking, for the trait always follows the distribution of this particular chromosome.

Imagine a father whose X-chromosome carries this peculiarity. He produces spermatozoa of two kinds, namely, X and Y; and in mating these encounter egg-cells all of one type, namely X, for that is the only kind of germ-cell the female produces.

Then from the mating, all this father's sons, with their XY combination, will be free from color-blindness; they will not even transmit it, for they all receive only the Y from their father, the X which they contain invariably coming from the mother.

On the other hand, all of the daughters (XX) will have the affected X; for although the X they receive from their mother is unaffected, the X they receive from their father is affected—he does not possess any other kind. Hence all of the daughters will have one recessive gene for color-blindness.

Ordinarily one gene is not sufficient to produce much effect in females, although they may have a minor degree of disability. In other words, it is recessive to the normal vision. But one gene does make them able to transmit this trait to their own offspring.

The male with one gene is color-blind, for there is no other X in his cells to mask the effect of the one which carries this trait.

All this sounds much more complicated than it really is. If one follows the X-chromosome through two or three generations, by making a diagram (Figs. 9, 10, 11), the distribution is seen to be simple; and wherever the father's X-chromosome goes, color-blindness goes with it, being always expressed in the males, but not expressed (although it is transmitted) by the females to a marked degree, unless it has come to them from both parents.

So if a color blind man marries a normal woman, all their boys will be normal, and the descendants of these boys will be free from the abnormality. All of their girls, on the other hand, will be carriers of the defect and, married to normal men (which will usually be the case) they will transmit the defect to half of their children of each sex: but only the sons will be markedly color-blind.

This distribution explains why color-blind boys are so much commoner than color-blind girls. But it must be added that in this, as in all other traits, it is to be assumed that the defect may occasionally arise in some other chromosome, and follow a commoner mode of distribution,—or even a less common mode, for that matter. Thus there is an account (59) of a family in which

color-blindness was passed from mother to daughters alone, in a Belgian family, for five generations. It is not recessive here, then, but dominant, and apparently either a female-sex-linked dominant, which for some reason could not manifest itself in the male sex; or else a female-sex-limited dominant. There are various other complications (388).

It should be borne in mind that there are three essential points of difference between the sex-linked and the sex-limited types of distribution of an inherited trait:

The sex-linked trait is (1) due to a gene located in a sex-chromosome; it (2) has no physiological connection with either sex, but is merely associated with one accidentally, because of its location in this chromosome; and it (3) occurs in some, but not all, of the members of a given sex.

The sex-limited trait, on the other hand, is due to a gene which (1) may be located in any chromosome except the sex-chromosome; (2) its association with sex is not accidental, but physiological; and (3) it is found normally in all the members of a given sex and in none of the opposite sex.

In spite of exceptions, color-blindness is associated so regularly with the X-chromosome that it has always been considered the stock example of a sex-linked character which, broadly speaking, is *transmitted* by the females but *manifested* by the males.

Because of the X-Y mechanism, the son receives fewer genes from his father than from his mother. All the genes carried in the father's X-chromosome must be lacking in a son, because this chromosome will always go to a daughter. The son can receive X-chromosome genes only from his mother, because he gets his X-chromosome invariably from her, mated with the Y-chromosome which comes from his father. Hence it might be supposed that on the average there would be a greater resemblance between father and daughter than between father and son, and that sons, on the other hand, would tend more to resemble their mothers.

This idea is maintained by the proverbial lore of many coun-

tries, particularly the Arabs (297). Among these a man is supposed, because of this type of inheritance, to resemble most closely his maternal uncle. Says a proverb, "A boy, if he turns out badly, belongs two-thirds to his mother's brother," that is, two-thirds of his traits are like his uncle's, specifically his bad traits—a delicate way of paying a compliment to one's wife's relatives! Another proverb commands, "Take girls from the breasts of their father's sisters," i.e., in choosing a bride, judge of her by her father's sisters, whom she will resemble just as a boy resembles the brothers of his mother.

There has been a slight amount of evidence brought forward in support of this idea, but it needs further investigation, since there is also evidence that contradicts it. The sexes differ in only one chromosome out of 24, hence the difference in heredity from this source would on the average amount to only one-twenty-fourth of the total, and would be difficult to establish statistically, even if it exists.

Night-blindness, the inability to see well in a dim light, is sometimes inherited in the same manner, but more frequently it is a straight Mendelian dominant, passing down from either parent to any of the children. The best-known family showing this trait is made up of the descendants of Metzger Nougaret, a Frenchman born in 1637. It is thus definitely known and charted through 10 generations, nearly 300 years; and it furnishes the largest genealogical table ever constructed in the scientific study of heredity (252). If the defect is in the sex-chromosome, it produces much greater abnormality in the eyes, particularly short-sightedness and squinting; if in some other chromosome, it does not produce these additional defects.

Nystagmus is a nervous affection which causes the eyeballs to flicker or move continually, either back and forth or up and down. In severe cases the head nods in the same way. It is found commonly in albinos, and sometimes even in those light blonds who represent merely the higher levels of albinism. It has been calculated (153) that about one boy in 5,000 and one girl in 10,000 has

nystagmus in Holland; perhaps similar figures would be found in other countries populated by the white races.

Most of the inherited cases seem to fall in two groups, one an ordinary recessive, the other a sex-linked recessive.

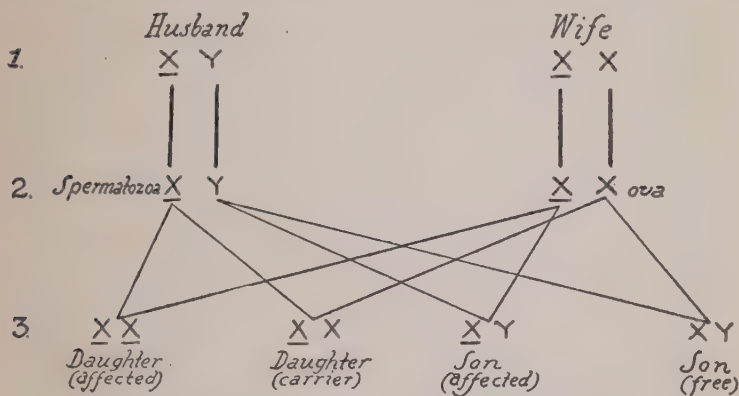


FIG. 11. THE INHERITANCE OF COLOR BLINDNESS

Here a color blind husband is supposed to have married a woman who is a carrier of the same defect. All the daughters will be either carriers of it, or will get a double dose and themselves be color blind. Since the latter outcome is rare because it is not often that a girl has parents both of whom are color blind or of color blind stock, it is sometimes said that a sex-linked trait like this is *transmitted* by women but *manifested* by men. A woman who receives a single dose of the trait (that is, a single gene, from one parent or the other) will transmit this to her progeny, but it takes a double dose to produce an effect in her, since the gene is recessive to normal eyesight. In the boys, on the other hand, the affected X chromosome has no normal mate, but is paired with the Y which does not contain similar genes; hence there is nothing to mask the effects of a single dose and a boy who receives the gene from only one parent will be color blind. The distribution of genes of other sex-linked characters can be followed by making diagrams similar to this and the two preceding, in which any type of mating may be taken as a start, and the results carried out graphically.

However, not one-half of all the cases to be found are inherited. Thus it is stated that half the coal miners in Great Britain get nystagmus sooner or later; it disappears usually within a few months after stopping work. It is rare among coal miners in the

United States. The causes are still obscure, but it is supposed that the greater depth of the mines in Great Britain and the miner's frequent necessity of working while lying on his back may have something to do with it. The number of cases increased enormously when the companies began to grant compensation for it as for other injuries—good evidence that it is functional rather than organic in these cases.

Strabismus (squint or cockeye) is found in at least one or two out of every hundred white children, but it is 10 times as common among the relatives of squinters—a strong indication that it is largely due to inheritance. It is equally common in the two sexes.

There are two types, the convergent, in which the eyes are "crossed" and which generally accompanies far-sightedness; and the divergent, in which the eyes look in opposite directions, and which is usually accompanied by near-sightedness. Both types may be found in the same family—indeed, a child may start with one type and then change to the other. There is some tendency toward spontaneous cure (64).

CHAPTER VI

THE EARS

The ears are among the more variable parts of the body, differing on the two sides of the head sometimes by as much as 10 per cent. As compared with the lower animals, man's ears, (and also those of the orang utan), have been and are being greatly reduced in size, while the lobe is increasing in size. Irregularities of the latter are large; the lobe is often adherent or merged in the skin of the cheek,—an inheritable trait (44) which recalls the ears of the anthropoid apes, among whom only the chimpanzee ever has a real ear-lobe, and that rarely.

In an inbred community on a small island, at least one ear was grown to the head in one-third of the population. Sometimes one could scarcely say that there was any lobe. There are striking contradictions of opinion as to the exact mode of inheritance, among those who have studied this trait (162). But the fact of inheritance is brought out by the greater similarity of the ears in one-egg as compared with two-egg twins (384).

The Cagots (Campagnets, Caqueux etc.), a sort of pariah caste in southwestern France, were supposed to be distinguished by shortness of lobe of ear; as they intermarried continually, this adherent lobe had probably become widespread.

The external ear is wanting altogether, on one side of the head or both, in some families. While its absence is still considered unpleasant, just as it was in the days when cropping the ears was a common form of legal punishment, the internal ear is of much greater importance to civilized man, the external ear apparently serving no useful purpose except in the rare instances when the control over some of the ancient and usually rudimentary muscles permits the Life of the Party to wiggle his ears as his contribution to the gaiety of the gathering.

Of the 75,000 cases of deafness in the United States, from one-

fourth to one-half are said to be inborn. The remainder represent the effects of accident or usually disease, the most frequent causes being meningitis, scarlet fever, measles, influenza, and infantile paralysis, in the order named. Deafness of this sort is usually acquired before the age of 4, rarely after the age of 10.

Since not all children who suffer from one of these diseases become deaf, it is conceivable that the deafened ones are those who had a weakness of the inner ear, and that they might transmit this weakness to their offspring. On the whole, however, deafness from this source is of minor importance in connection with heredity.

Nor is all the inborn deafness due to inheritance, for an important part of it is the result of congenital syphilis. The presence of such cases in published pedigrees of deafness makes it difficult to determine what the real hereditary relations are, and probably none of the studies yet made has succeeded wholly in avoiding this and similar sources of error.

The number of children born deaf is said to be one in two or three thousand. When all the foregoing causes are eliminated, it is probable that less than one-half of all those who are deaf from infancy are deaf from inheritance; or in other words, probably 20 to 25 per cent of adult deafness is due to heredity.

On the other hand, one of the common causes of deafness, otosclerosis, appears later in life, usually toward the end of adolescence. The subject gradually becomes more and more hard of hearing, through failure of the auditory nerve, until he is almost, though not quite, totally deaf. This is, in most cases, distinctly based on heredity. Some students have described it as due to dominant, others to recessive genes, a strong indication that it may be inherited in different ways, as one would expect.

Congenital inherited deafness is generally said to be due to either one pair or two pairs of recessive genes; but the variety of ways in which deafness may be brought about makes one suppose that the inheritance, if more finely analyzed, would also be found to be various. The inner ear is a nicely adjusted mechanism: deafness may be produced by any gene, the operation of which in develop-

ment tends to disturb this adjustment, or results in the impairment of some necessary part; it may also be due to an effect on the auditory nerve, or on the center of hearing in the brain. The history of deafness due to disturbance of the labyrinth often suggests the presence of dominant genes.

When two parents who are by inheritance congenitally deaf marry, their offspring usually are all deaf. Such marriages were formerly common in institutions for the "deaf and dumb;" nowadays they are rare because it is generally recognized that they are undesirable, although there would be no objection to them eugenically if one of the partners were sterilized prior to marriage.

Most deaf children are the offspring of parents, neither of whom is deaf. This points plainly to the action of recessive genes. They are frequently the offspring of cousin marriages, because related recessive genes are thus brought together.

Dominant genes, on the other hand, are not significant in this way in cousin marriages; that is to say, they will not be brought into expression any more frequently in the marriage of relatives, than they would be in the marriage of wholly unrelated persons.

They have another and an ill-omened importance, however, which makes it impossible to leave them out of consideration in discussing the marriages of kin. In some instances, it appears that a dominant abnormality produces its customary effect only when it comes from one side of the ancestry. If it comes from both sides, so that the offspring gets a double dose of it, the effect is fatal—either the embryo dies or, at most, the child can not survive long. The first recorded case (243) concerned such an apparently harmless abnormality as short fingers. Two cousins, each with this dominant trait, married and produced a child so badly crippled that it could not survive the first year of existence. Here it seems probable that a gene was involved, one dose of which produced only a slight abnormality; two doses a fatal one. Abundant illustrations of the sort could be cited from the breeding of lower animals. Hence cousin marriages, when both individuals show the same dominant abnormality, should be regarded with suspicion.

There are some combinations of genes which create deafness along with other marked abnormalities. The most common is mental defect, which is produced in many different ways. A perturbation of development which is great enough to cause imbecility is also, as one would expect, sometimes great enough to affect the center of hearing in the brain. The two defects may, however, be quite independent, and simply brought together in a family by chance. Or such a disease as scarlet fever may produce both deafness and arrested mental development.

Another, rare one is a defect in the development of the bones, which leaves them abnormally brittle. The bones of the middle ear are affected like others, and there is a characteristic pale blue appearance of the eyes (344). It seems to be inherited quite definitely as a dominant in most cases (69), but a family has also been reported (322) in which the brittleness of the bones was dominant, but the blue sclera of the eye was not, since persons with normal eyes had fragile bones; and in some other families deafness does not accompany this abnormality. Here as usual each family is within limits a law to itself.

While all genes probably should be considered modifiers of each other, yet in specific instances there are certain genes which produce such a pronounced effect on a given trait that they are properly looked on as modifying that trait; and as the modifiers change in different matings, so will the expression of the trait under discussion be altered. The effects of modifying genes may be either cumulative, increasing the effect of a given gene, or reductive, diminishing it, or alterative, changing its character as in the instance mentioned in the preceding paragraph. When it is further borne in mind that the expression of almost any gene may be altered, for the time being, by changes in either (1) the internal environment (hormones, etc.), or (2) the external environment, one will not expect the facts of inheritance to fit into any simple, rigid, mechanical scheme,—because nature itself does not fit into such a scheme.

To take an illustration familiar to everyone who has gone

through grammar school science, it is impossible to state accurately the number of bones in the human body. Some people have more than others; the child has more than the adult, since some bones are separate in early life that fuse together in later years.

It is possible to give the mean or arithmetical average of the number of bones; it is possible to state the most frequent number. But no one can tell *the* number, nor even the "normal" number, since any number that permits its possessor to lead a normal life must be considered normal, and there is the possibility of wide variation here.

But if one can not even state with precision such a fact as the number of bones in the body, one would expect still less to reduce to geometrical patterns of cast-iron rigidity the effects of interaction of the thousands of genes in the cell. General tendencies are all that one could ask. Heredity is a statistical science.

CHAPTER VII

THE HAIR

Several months before birth, the baby's body is covered with a downy hair known as the lanugo. This is generally thought to represent the coat which his ancestors had at some period when they resembled the apes of today. Occasionally it persists into adult life and grows long, in which case the problem of vocational guidance is simple—the child will be welcomed by any sideshow as "The Missing Link." In such hairy persons the toenails and fingernails are usually defective, as if some of the substances that should have gone to form them had been diverted to hair. While such a condition is inherited, it appears so seldom as to be merely a "freak of nature."

There are other, somewhat less rare cases in which the nails are lacking, without evident abnormality in other parts of the body. The nails of either hands or feet or both may be thus affected. In one case 36 out of 55 members of a family, traced through six generations, lacked nails (62). Occasionally defect of fingernails is associated with congenital absence of the knee-cap. As both these abnormalities are excessively rare, the chances are against their occurring together by accident: they probably have a common cause (6).

At birth the infant by no means shows what his hair will be in adult life. The color, particularly, darkens with age in most cases, due to the increasing action of the ductless glands, particularly the suprarenals and thyroid which largely govern the growth of the hair. Occasionally a baby's hair is darker at birth than it will be a few years later: possibly the influence of the surge of his ductless glands, just before birth (p. 248), governs this. But the normal course is for the hair to darken gradually during childhood and adolescence, until it is replaced by gray hair in old age. As a result of glandular changes, one might even have hair dark at birth, light in childhood, dark in maturity, light in old age, and darken-



FIG. 12. A WHITE BLAZE IN THE HAIR

Of all the common peculiarities of human coloration, one of the most striking is a white streak or forelock in the hair. Sometimes it is much smaller than the one here shown; it may even confine itself to such a small area as part of an eyebrow. It is inherited, and in this family is a simple dominant, which has been traced through six generations and, according to family tradition, goes back to Harry "Hotspur" Percy, who died in 1403. In another family it appeared only in males; a female could transmit it to her sons but did not herself show it. Photograph from Dr. Newton Miller, professor of microscopical anatomy, University of Utah.

ing again before death; but such a case would be like the weather in California,—“very unusual.”

In the old American stock, grayness manifests itself unusually early, and the males gray faster than the females (178).

That the color of the hair may be altered by outside influences is proved not only by X-ray experiments but by the occasional cases in which it turns gray as the result of shock or fright. Marie Antoinette's hair grayed in a short time before she went to the guillotine. That of A. W. Greely, the arctic explorer, turned white during the anxieties incident to his position; after he was rescued it regained its color gradually, but was never again quite such a dark brown as it had been before. The instances described in fiction where hair turns gray overnight as a result of shock are not much of an exaggeration of the facts.

In such cases, the grayness is due to the invasion of the hollow hair by fine bubbles of air which reflect the light and prevent the pigment from being seen. The normal process of graying is altogether different, depending on the exhaustion or death of certain cells in the scalp which produce the pigment. When a dark hair falls out, it is replaced by a new one which contains no pigment. The woman of 35 who looks anxiously in her mirror is not searching for a partly gray hair: she knows that if she sees the Dread Messenger of Death it will be a wholly gray hair which has supplanted a brown one that has lately fallen.

I knew of a boy of 15 whose hair turned gray rapidly. Such cases are abnormal; in fact, this boy died shortly after. Ordinary graying is a perfectly natural change, due to the normal ageing of the body under the influence of inherited predispositions; and there are marked differences in this inheritance, some families having a tendency toward grayness at a much earlier age than others.

In one such family (268) the hair became gray in youth, in a definite proportion of the members, for at least five generations, and family tradition was probably correct in saying that this gene could be traced back through as many hundreds of years, for an

old Gaelic curse, said to have been pronounced against the family in the fourteenth century, runs:

In the time of most numbers shall weakness come o'er them,
In the time of most weakness shall strength then restore them;
In their prime in their youth like the rushes they'll grow,
As withers the bracken be their manhood laid low;
O'er the child's clustering ringlets shall age spread its snow.

The history of such genes as this, which continue generation after generation to produce the same definite effect in precisely the same manner, unaffected by their surroundings, is one of the most striking things in the whole study of heredity.

The minuteness with which a gene may work is shown by the hair on the middle segments of the fingers and toes. About one-fourth of all white Americans seem to lack this hair; most Indians and Negroes lack it; and the absence has been shown (66) to be due to a single pair of recessive genes. One finger or toe, or all of them, or any number between, may be affected, the variation presumably being due to the modifying effect of other genes. If hair is absent from the middle segment of the ring finger, it is almost invariably absent from all the others.

The question, What is the minutest biological unit transmissible by heredity, was one that appealed to Francis Galton. It has never been answered. Such an effect as the one just mentioned is small enough, but experimental breeding of the most delicate kind has shown differences due to single genes down as far as the ability of the human eye can distinguish, as in the eye color of the fruit fly or the petal color of the snapdragon.

If Sir Francis were studying heredity now, he would re-word his question, for all that is transmissible, physically, is the gene, which is generally considered the ultimate and indivisible unit of inheritance. There is a slight suggestion that the gene itself may be made up of smaller units, or perhaps that the division which it must undergo whenever the chromosome splits is foreshadowed in some internal arrangement; but this must be left to later research. The minutest biological effect produced by heredity is undoubtedly beyond the power of the microscope to detect.

Different genes probably control the number, length, shape, color, growth, and arrangement of the hairs, but the general pattern of the head hair is well fixed, and the relatively slight variations indicate that it has been rooted in its present soil, so to say, for millions of years. Marked variations from the ordinary are properly looked on as abnormal. That the various genes are quite distinct is shown by the fact that although all sorts of people have been intermarrying in Europe for several thousands of years, there is no tendency toward a general blending of hair colors: blacks and reds, blondes and browns, still are found side by side, indeed in the same family.

In general, the darker colors are dominant over the lighter, as with skin color. Offspring will not have hair darker than that of the darker of their two parents. Occasional exceptions are due to the accidental coming together of a number of different but complementary genes.

All the evidence indicates that brown hair, which is still characteristic of the overwhelming bulk of mankind, is the "original" type, retained by apes and monkeys. The lighter shades have been produced by dilution of the darker ones, this dilution taking place along several different lines (410).

One of the commonest and most strongly inherited of the minor variations is a white lock, streak, or blaze in the hair. This is usually passed on indefinitely from parent to offspring as a simple dominant. In one case (237) it was traced for six generations, and family tradition carried it back to a posthumous son of Harry "Hotspur" Percy, born in 1403.

It is also said to have been a peculiarity of the Venetian doge Marino Faliero (1278-1355) and to exist still among his descendants.

A blaze in the hair is wholly different either from gray hair in general or from albinism; it is rather to be compared with the white spotting that occurs in almost all breeds of domesticated animals from time to time. The white blaze in the hair represents the white spotting pattern reduced to a mere vestige, just as does

the white star on the forehead of a horse. Sometimes it is not so far reduced, but is accompanied by white patches in the skin, just as in horses, where a star may be associated with a white foot, or several of them. This piebald effect seems to appear occasionally in crossbreeds, which gives rise to the surmise that it may not be an ordinary, simple mutation, but some sort of an interference or dilution effect of genes producing pigment. More investigation is necessary to determine just how it takes its start. It is conspicuous in colored people, and spotted Negroes are occasionally exhibited in sideshows.

The inheritance is not always that of simple dominance; at least one family has been noted (174) where the white lock shows only in the males. It can, however, be transmitted by a mother who does not herself show it, to a son who does. In such a case it is to be supposed that the trait depends for its expression on some particular hormone of the reproductive glands, and that the secretions of the ovary do not have the same effect in bringing it to light as do those of the testicle. In other words, it is dominant in males, recessive in females. In another family it appears to be an ordinary sex-linked gene located in the female sex-chromosome.

Conditions are somewhat similar in connection with pattern baldness, that is, the type which results in loss of hair in a definite area of the scalp. It is seen characteristically in the portrait bust of Hippocrates, which also suggests that the pattern is of great antiquity and has been perpetuated generation after generation regardless of styles of headgear, habits of living, types of hair brushes, sanitation of barber shops, and improvement in tonics. The exact pattern is inherited with a good deal of constancy from parent to offspring (256). That it is sketched out very early in the life of the individual is shown by its occasional presence at birth. In such cases the blank space will be filled in by hair in a few weeks or months, and will not show again until this hair drops out at some predetermined time in adult life, this time also being a matter of constitution. C. Julius Caesar was bald before 30, much to his chagrin.

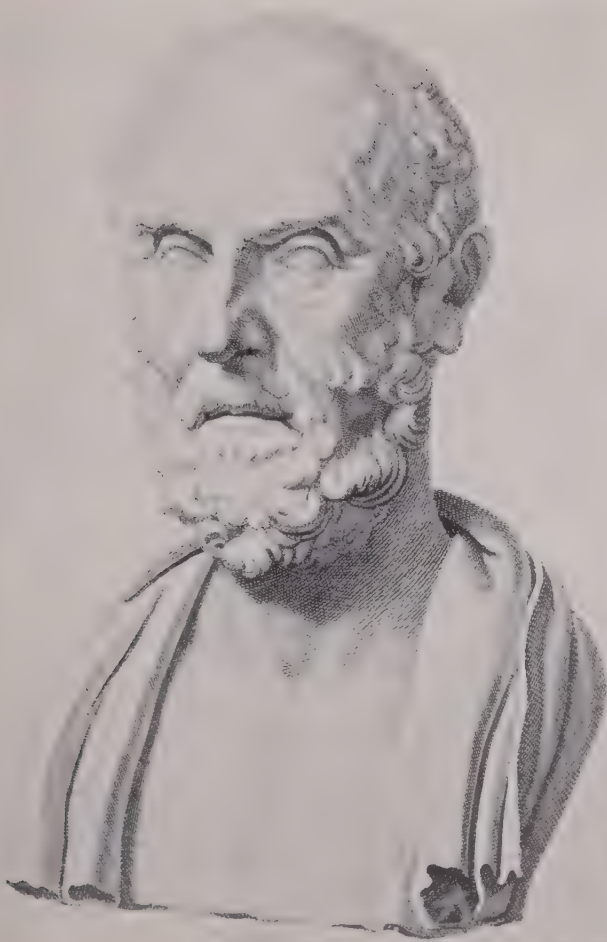


FIG. 13. THE "FATHER OF MEDICINE" WAS BALD

This supposed bust of Hippocrates of Cos (460-357? B.C.) proves that pattern baldness is no novelty, and that it is not due to tight hats or any of the other things that are sometimes blamed for it. As a fact, it is an inherited trait which is transmitted in the same way as horns in sheep, being dominant in men and recessive in women. Baldness of this sort is sometimes referred to as Hippocratic baldness.

In other cases the baby is born with a complete head of fine hair, which shortly falls and then grows in all over again.

Generally, the wearing of tight hats and other causes blamed for pattern baldness have nothing to do with the case. The pattern is one of the inherited possessions of the family, and is passed on just as are horns in sheep. It goes directly from father to son, acting as a dominant; the mother can transmit it, but it acts as a recessive in her sex and does not show unless she has a double dose of it, coming from both her parents. But as this situation is rare, baldness of women is also rare.

However, it appears, as one would expect, that a single dose, while not producing a complete bald head in woman, yet may have some effect. If the hair of such a woman falls out during illness, it seems to have less vigor of growth, and partial baldness may result. On the other hand, a woman who loses her hair as the result of typhoid fever, for instance, but who does not have any tendency to baldness in her germ plasm, usually finds after a few anxious months that a full head of hair, just as good as before, grows in.

Such pattern baldness must not be confused with complete and abnormal baldness, with which it has no connection in heredity. Sometimes this type of baldness appears at birth and extends to the eyebrows, the hair and nails also being abnormal. In one family it appeared in three generations. Grandfather, father, and mother were bald from birth. Seven sons and one daughter never had any hair. The only grandchild, son of the oldest boy, has the same trait (256).

In another (16) a man's whole head was bald from birth; all the rest of his hair was normal and he presented no other anomalies. He married successively two normal women. By one he had three children, by the other two; all of these children were bald on the head, with a slight diminution of facial and body hair. There is no explanation in the ancestry: this looks much like a new dominant mutation.

Denudation of hair of the entire body in adult life is due to some

upset of the glands of internal secretion, principally the thyroid (48). But the secretion of the testicle has also a marked connection with baldness, as is evidenced not only by the rarity of baldness in women but by the asserted fact that eunuchs never become bald. A great shock will so derange the internal secretions as to produce baldness, as was shown by men who, after harrowing experiences in the World War, lost all their hair, head and body, except the eyelashes (403). Injury to nerves may also produce loss of hair; and syphilis is perhaps the most frequent cause of all. The prophet Isaiah (III, 17 and 24) was not in error when he warned young men that their hair might fall out if they associated with prostitutes.

The connection of hair growth with the internal glands is shown interestingly in a woman whose hair grew whenever she was pregnant, and invariably fell out all over the body when menstruation returned. At the menopause hair frequently begins to fall out on the scalp and at the same time to grow on the face, —synchronously a marked readjustment of the system of internal glands is going on. If the rules could be worked out, the hair might be found to be the most delicate index of the action of these glands. Its growth follows closely the growth curves shown by young animals in general; but it varies in different parts of the face, as well as in different persons (341). Many men suppose that their mustaches and beards grow faster in warm weather than in cold. If this is so, it may be due to the influence of temperature on the secretions of the testicles. There is no doubt that the latter markedly influence the growth of facial hair, particularly that of the middle upper lip and the upper sides of the face. That of the chin and sides of the lips is said to be affected more by the pituitary gland.

In masculine women, and in others with advancing age, but more among Mediterraneans than Nordics, the tendency is for hair to grow on the upper lip and the point of the chin, rather than on the sides of the face. The latter must therefore be considered the area of true masculine facial hair. Elsewhere, I recall the



FIG. 14. INHERITANCE OF DOUBLE CROWN

About one white person in 20 or 25 has two crowns or occipital whorls of hair instead of the customary one. "He that hath two crowns to his head shall eat his bread in two kingdoms" says a comforting proverb that, as is often the case, may be interpreted in any way one prefers. These two brothers suggest that the double-ness is inheritable, and both pedigree studies and examination of twins confirm this. The direction of the single whorl is also inherited. Photograph from Edwin Tenney Brewster, Andover, Mass.

familiar fact that the Mongolian race shows peculiarly feminine characteristics, presumably based on the action of the internal glands. This extends to the distribution of facial hair. A Chinese mandarin with the whiskers of Ambrose E. Burnside¹ would attract attention at once. In general the Eskimos and North American Indians, who are closely related and both derived from the Mongolians not long ago, may be called the races of the earth that are poorest in hair. Who ever saw one of them with a Van-dyke beard? The rarity of baldness among these peoples may also be associated with the "femaleness" of their constitution.

The form of the hair is set by inheritance and is dependent largely on the shape of the cross-section (68, 208). A round hair usually remains straight, while one that is flattened tends to be curly, reaching an extreme in the tight kinks or "peppercorns" of some African peoples.

Curliness in the white race generally tends to be dominant over straight, and has even been called a simple Mendelian trait, with waviness representing the hybrid condition; but this requires further study. The opposite relation has been reported in some colored races. The child's curly head of hair tends to straighten out with age, presumably as the result of glandular changes such as those which darken it; on the other hand, the pubic hair curls at adolescence, the appearance of the definite twist or kink in this being perhaps the best single sign of the completion of puberty.

The crown or whorl of hair on the occiput may point in the same direction as the hands of a clock rotate, or the reverse. In both America and Germany, about 75 per cent of white children show the clockwise whorl, 18 per cent the counter-clockwise; and the remainder have two or more whorls. The whorl has been described (19) as a simple Mendelian trait, with the clockwise direction dominant. Its direction should govern the way in which the hair is

¹ This general officer of the northern army in the American civil war gave his name to his own tonsorial type, which consisted in shaving the chin and wearing the hair long on the side of the face. By a facetious inversion, "burnsides" are sometimes known colloquially as "sideburns."

parted, for if the division is made on a line not favored by the whorl, the comb will always find difficulties.

Many babies show a natural line of parting in the hair, which is part of the inherited pattern and should again guide the application of the comb. This line has of course been interpreted by some writers as the inheritance of the effects of the maternal hair-brush in past generations. Unfortunately for this brilliant explanation, the part often runs down through the eyebrow. It is, then, necessary to suppose that the child of past generations regularly had one eyebrow parted when his hair was brushed for school in the morning!

The double crown is inherited (31); but presumably identical twins are reported, one of whom had a single crown, the other a double one. The occasional cases in which an individual has a number of crowns would probably furnish the start for the production of a new variety of human comparable to those fancy domesticated varieties of guinea pig in which the hair all over the body is arranged in crowns or rosettes (214). Some oriental races, in fact, do have a whorl in the downy hair in the middle the back.

CHAPTER VIII

THE TEETH

In skulls of the old stone age, decayed teeth are hardly found. In the new stone age, when a new race appears in Europe, bad teeth also appear, and by the prehistoric period they have become common. Plenty of them are to be seen in Egyptian mummies. In Europe they have been abundant ever since, and the increase in defective teeth has not been as great during the past 500 years as is sometimes supposed. On the other hand, skulls of American Indians who died several hundred years ago show almost no decayed teeth.

Evidently the tooth decay which has aroused so much comment during the last generation is not a simple matter. In the United States at the present time, Negroes and Italians have much better teeth than the Nordic whites or Irish, for instance. This can not be attributed merely to more faithful use of the toothbrush and Sapona's Dentifrice. Certain peoples, as the Zulus (364) and the inhabitants of some of the Canary Islands, are noted for good teeth and yet never saw a toothbrush.

On the other hand, a study of 1,000 British girls and boys, ages 13 and 14, showed that there was no relation between regular use of the brush and the number of decayed teeth in the child's mouth (317).

A family has been described (340) in which, during the three generations known, there was a striking tendency to early decay and loss of teeth. This might be ascribed to family habits; but when it is found to affect only the females, the males being all free from it, one can hardly avoid the conclusion that it was associated with the inherited constitution of the women and girls.

Again, in identical twins it has been found that decay usually attacks the same teeth (397). And in any case, decay is frequently

bilateral, which suggests that the causes are internal as well as external.

The tendency toward early decay of the teeth, then, seems to be an inheritable and racial trait. No reasonable precautions should be neglected; but if, in spite of these, children have bad teeth, parents should not blame themselves unduly for failure to prevent it. It is questionable whether, with the best of care, children of Nordic ancestry can avoid the difficulty altogether.

A racial trait, I might point out parenthetically, is one which occurs in people by virtue of the race to which they belong. The term is often used loosely, and should be employed with more discrimination. Diabetes, for instance, has been called a Jewish racial trait: but (1) the Jews are not a race at all, merely a socio-religious group made up of numerous races, the proportions varying in each country; and (2) they suffer from diabetes because they eat too much. A lean Jew is less likely to be diabetic than a fat Gentile. Again, certain defects found among the Jews have been called racial traits, whereas their frequency is due simply to the fact that consanguineous marriage has been commoner among Jews (because of segregation and religious barriers) than among some other peoples, and therefore has brought recessive traits to light (compare the remarks on deafness, p. 39).

On the other hand, woolly hair and low resistance to tuberculosis are racial characteristics of a Negro: he will have them wherever he lives, whatever his habits are, and whomever he marries. A form of broad, flat incisors known as "shovel teeth" is common enough among American Indians to be called a racial trait.

There are many inherited anomalies of the teeth (86), a common one being the absence of a tooth, or of several of them. The ones that disappear are usually the upper incisors, and it is supposed that they are "pinched out," so to speak, by excess crowding when the face grows together in front. There are naturally all grades of this defect, due to the presence or absence of modifying factors in the development; and it seems to be variously dominant or recessive (372). Sometimes one tooth is gone and its mate on the other

side of the face is merely reduced in size; in extreme cases all the front teeth may be missing. A case (which I have authenticated) has been reported by the newspapers from Poplar Bluff, Missouri, in which two brothers and a cousin have no teeth at all, although normal in every other respect. This is a much less serious defect than that characterizing the Bhudas, a group dwelling in Hyderabad, Sindh, India, who are toothless: in their case, (as in the Mexican Hairless dog) the gene also produces baldness and great sensitiveness to heat. The trait is reported to be a sex-linked recessive among the Bhudas (368), while it seems to be a simple recessive in the dog (293).

Mal-occlusion, or the failure of the teeth to meet properly, is a childhood condition which causes much anxiety to parents and gives much work to dentists. The jaw is too small for the teeth and the latter are overcrowded, necessitating a long and painful process of spreading the jaw.

This is sometimes explained as being due to the lack of sufficient chewing to strengthen the jaws of the ancestors. It is supposed that civilized man does not use his jaws enough, and the effects of this disuse are inherited from generation to generation, so that the jaw grows smaller and smaller.

The explanation is a work of art. Nothing suggests that the effects of disuse can be inherited in this way. The reduction of the jaw must be regarded as part of the general evolution of man, just as is the reduction of the little toe, which is now nearly useless in all civilized people, and in at least three out of 10 whites is rudimentary, two of the joints being solidified, sometimes even in the fetus. Exactly the same condition, in a high degree, is found in many old Egyptian mummies; yet at that period and previously most people went barefoot and disuse of the little toe in tight shoes offers no explanation. Moreover, the degeneration of this toe is at present some three times as common among Japanese as in the white races, but there is nothing in their ancestry or surroundings to explain such a change; nor in those of the Hottentots and Fuegians, among whom it is frequent.

All grades of transition are found between this reduction of the little toe, and the full short-fingered condition (p. 104). The fact that the toe of two segments is as common among Japanese as that of three segments is among whites is probably associated with the shorter stature and different proportions of the entire Japanese skeleton. It will be noted that the short-fingered people were found to be a little shorter in stature than the average. The great toe has already been reduced to two segments; perhaps a similar result is in sight, among certain peoples at least, on the opposite margin of the foot. If so, the long-range speculator can look forward to a time when man, like the horse, will run on his middle toenail, everything else having disappeared! The thumb has long since been content with two segments, and in some peoples, as the Aztecs, a frequent reduction of the little finger is said to occur, parallel to that of the little toe which has just been described. The extremities of both arms and legs, then, show a tendency toward the same direction in evolution, as one would expect them to do.

Parallel cases are common enough in evolution. An organ not only may degenerate, as has the eye of the cave fish (292), but it may on the contrary increase in size until it becomes a handicap to its possessor. The familiar illustration of this process is the Irish stag, whose horns kept growing through the centuries until he could hardly support them: it is thought by many that the species became extinct largely because its horns grew to be too big a burden for it to drag around.

An explanation may be found along several different lines of inquiry. If an organ is useless, as eyes are to the cave fish, and as the little toe possibly is to men and women, (one of the sons of George V is said to have had his little toes amputated for convenience), its perfection will no longer have any value; the possessor of an inferior specimen will fare just as well and leave just as many children, like himself, as does the owner of a good one. Hence variations will tend to pile up in this organ, there will be no selection to eliminate the unfavorable ones, and as the latter

are bound to be more frequent than variations which would tend to make the organ more perfect (see p. 269), the natural result will be the perpetuation of the organ in a deteriorated state.

The reverse process, in which an organ keeps getting bigger and bigger, until it seems to pass the limits of usefulness or even of tolerance, may be due (1) to a chance series of mutations, all in the same direction; or (2) the need of the species to deal with a growing problem. If the animals on which a species feeds are continually growing larger, the species itself may have to become bigger and better armored, like the dinosaurs of old. Then if some cataclysm or disease wipes out its ordinary food supply the dinosaur, to follow the illustration, will be left with a size and armor not merely useless but detrimental. Or (3) the continued change may be purely incidental, an effect of some set of genes producing other and important effects, and with this, perhaps, putting the pituitary gland out of adjustment with the other glands of the body. To take a wholly imaginary illustration, the shrinkage of the little toe and jaw might be accompaniments of man's skin color, or his hairlessness, or something of the sort that is now an inescapable part of his make-up. Or (4) it may be due to structural changes that involve a complete readjustment of the animal's make-up.

The changes in the face, which have been one of the conspicuous features of man's evolution, may be explained in one or several of these ways. They can not be explained by the direct effects of use or disuse; and desirable as wide shoes and chewable food are for a child, they will not turn back the hands of the evolutionary clock.

The facial changes occurred relatively late in man's ancestral history. The shortening of the animal muzzle straightened up his front teeth and also provided him with both a chin and a nose, as compared with what pass for such in a gorilla. Presumably this shortening of the muzzle is associated closely with the erect posture, increase in size of brain case, and balancing of head on neck, which brought about innumerable changes in the muscles

and in the adjustment of the skeleton. It also tended to crowd the jaw, so that the third molars (the wisdom teeth) are suffering greatly for lack of room, as is shown by late eruption, frequent abnormal position, general uselessness, and failure to erupt at all in perhaps one out of five persons.

It is also suggested that the crowded jaw of the American child is due to racial intercrossing. A race with large, roomy jaw and large teeth might mate with one that is small in these respects, and the children might inherit the large teeth of one parent, the small jaw of the other, with a resulting disproportion.

This is a mere supposition, with no evidence back of it (389). I have already mentioned the possibility (p. 52) that in such an organ as the eye, interbreeding might upset adjustments. Even this remains to be proved. The idea that the proportions of the jaw may be upset in this way or, as is equally alleged, that an individual may inherit a small trunk with large viscera to go in it, and so on, is not supported by experimental breeding and is out of line with modern genetics. It seems to suppose that there are certain elements in the germ plasm which determine large teeth, other elements which produce small jaws. This is in a measure true, as I have pointed out, but the experience of breeding small mammals of different sizes shows that there is room for a great deal of interaction and mutual adjustment in the developmental effects of the various genes, and that a pretty good compromise is usually reached by the time an animal grows up. Since the crowded jaw is easily explained as a part of the general progress of evolution, the burden of proof is certainly on those who maintain it to be the effect of race-hybridization; and so far no proof has been offered.

The statement has sometimes appeared in works of "popular science" that man's ancestors had four or five molars; that one or two have already disappeared and a third (the wisdom tooth) is now going the same way. This is fiction. Thirty-two as the total number of teeth has been established in man's ancestry for a long time. The occasional appearance in prehistoric skulls, and

even now, of a fourth or fifth molar is to be looked on just as is the appearance of a sixth or seventh finger or toe.

The time and order in which the teeth appear are affected by inheritance, as shown by family histories (9) and the study of twins (416). The teeth tend to erupt on the right side a little earlier than on the left (364) and there are wide variations in the date of appearance of the first one, which generally shows up at the age of six to eight months. It has often been said that this is associated with intelligence, the brightest children tending to produce teeth earlier. In a study of the family histories of mental defectives at a California institution, I could find no substantial evidence to support this belief, there being only the slightest suspicion of a negative correlation between mental age and reported date of eruption of the first tooth.

When the boys were divided into two groups, according to whether they had other relatives with mental defects or not, those with a tainted family history averaged 7.5 months, those whose family history was good averaged 8.7 months at first tooth. In a group of brilliant California high school students, L. M. Terman found the age at first tooth was 7.3 months for boys, 7.2 months for girls, with range from 5 to 14 months. All histories of teething have to be discounted somewhat, since they depend usually on a relative's memory years after the event; probably those of the high school students would be more reliable than those of the mental defectives; but so far as the available facts go, the difference is not great enough to bear much weight. Other studies agree in showing that the development of such features as the teeth is related to general physical development, but not much if any to mental development. The appearance of the first tooth may have some relation to the eruption of the permanent teeth (272), (which appear in girls six months earlier than in boys); but delay in the appearance of the first tooth, at least up to an age beyond one year, is no cause for surprise, and not nearly as much cause for alarm (to the mother who nurses her own offspring) as is the occasional surprise of a baby who has several teeth in sight at birth, as had little Jules Mazarin, the future Cardinal.

CHAPTER IX

THE BLOOD

When early man fixed on the blood as an index of kinship and began to speak of "blood relations" and to declare that "blood will tell," he doubtless had in mind some magical idea; but he was nearer the mark than he knew. Perhaps as much definite information about relationship can be had from the blood as from any other one feature of the body.

In red-blooded animals, the color in the red corpuscles is a stuff called hemoglobin. In lower animals this does not crystallize, but in the higher mammals it does, thereby at once forming a first index of their similarity to each other. Moreover, different kinds of animals have different forms of crystals, and those that are closely related to one another by descent have crystals most alike. Here is a second test of relationship.

A third and more delicate one is offered by the agglutination of the blood.

In normal human blood that has stood for a little while in a glass, the red blood corpuscles separate and settle to the bottom, leaving a clear serum; but if the tube be shaken, these red cells will move evenly through all parts of the serum, making a smooth emulsion. Now if the blood of another person be added to the test tube, the red cells of the first specimen may not show any effect. On the other hand, they may immediately lump together and fall to the bottom of the tube (Figs. 15, 16).

It is evident that the same result must occur in a case of blood transfusion from one person to another. It may therefore be a matter of life and death to give the patient the right sort of blood—a sort that will not cause his own to agglutinate and thereby produce a dangerous reaction.

It is now known that human bloods fall into four well defined groups, according to their behavior in this respect, and these are

commonly designated as I, II, III, and IV, the last-named being rare.

To abbreviate a long story (310), two different substances (agglutinogens) have been found in the red blood cells, which cause these cells to ball together into shapeless, tough, little masses when exposed to certain other substances (agglutinins) in the blood serum.

For convenience the agglutinogens in the cells may be called A and B. If one's cells do not possess A, one's serum will possess

TABLE I
Characteristics of blood groups

GROUP	RED CELLS	SERUM
I	Inagglutinable. Contains no agglutinin. (Universal recipient)	Agglutinates cells of the three other groups. Contains agglutinins a and b
II	Agglutinated by serum of groups I and II. Contains agglutinin A	Agglutinates cells of groups III and IV. Contains agglutinin b
III	Agglutinated by serum of I and II. Contains agglutinin B	Agglutinates cells of groups II and IV. Contains agglutinin a
IV	Agglutinated by serum of three other groups. Contains agglutinogens A and B	No agglutinative effect. Contains no agglutinins. (Universal donor)

an agglutinin (a or anti-A) which coagulates A. This is simply to say that one's blood can not possess both A and anti-A, or it would agglutinate itself. It is protected from this catastrophe by nature, just as the stomach is protected from digesting itself.

Either the agglutininogen A in the red cells or the agglutinin a in the serum might with equal propriety be designated as the inherited entity, but convention has fixed on A, so that a merely figures, usually, as the absence of A. The second pair, B and b, behave independently in the same way.

The cells may contain neither, either one, or both of the agglu-

tinogens, giving rise to the four types of blood, with an equal number of complementary types of serum. The physiological differences of these four types are shown most conveniently in tabular form (Table I), from which it will also be apparent that only certain combinations between them can be made with safety. Hence when a blood transfusion is to be made in a hospital, the first thing the doctor does is to test the blood offered by various donors, to see if it can be used safely. More commercially, he need only test the blood of his patient, and then from his card index of vendors pick out the one who offers the right specifications, and who is willing to open his arteries at \$25 a pint or whatever the market price may be.

The type of blood group one has seems to offer a simple and clear-cut illustration of heredity.

Hitherto in this book I have spoken of cases in which there were two complementary genes (or allelomorphs, to use the technical term), one coming from each parent. Blood grouping is an example of an important class of cases in which there are not two alternatives but a larger number,—in this case three (166). It is supposed that there was originally a recessive gene, O, related to the agglutinability of the red corpuscles. In due time this gave rise to a dominant mutation A, and later to another dominant mutation B. These three genes, O, A, and B, then, occupy the same point in a chromosome, and the individual can possess any combination of two of them. Without going into detail, the most generally accepted scheme names the groups as follows:

	<i>Genes</i>
Group I.....	OO
Group II.....	AA or AO
Group III.....	BB or BO
Group IV.....	AB

Since A and B are both dominant to O, it is evident that AA and AO will behave just alike, so that either combination results in Group II; and a similar explanation applies to BB and BO in Group III.

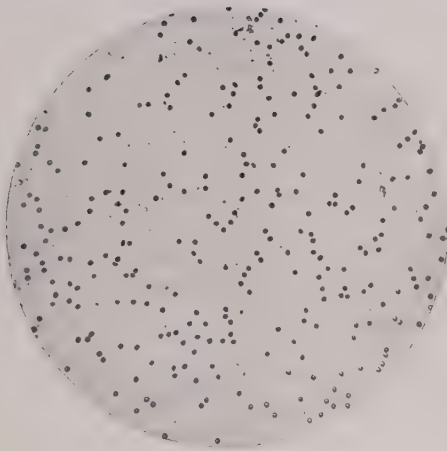


FIG. 15

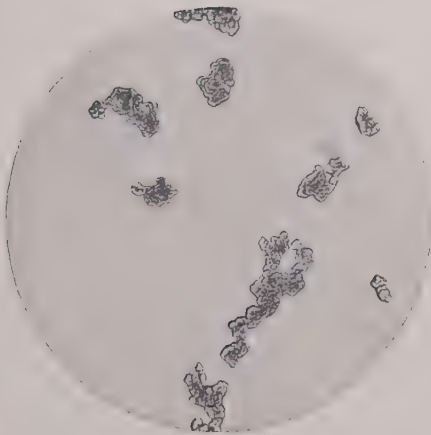


FIG. 16

FIGS. 15, 16. THE AGGLUTINATION OF THE BLOOD

Above are red cells in a physiological salt solution. Serum from the blood of another person, M., has been added but produces no effect: the cells remain separated from each other and spread evenly throughout the solution. Serum from a third person, but this time an "incompatible" person, N., is added to the solution, with the effect shown below. The red cells promptly clump together. Evidently if this effect were produced inside a man's body instead of in a test tube, the results would be serious; hence the importance of testing for blood type before a transfusion. Illustrations from Dr. Fritz Schiff, Municipal Hospital, Friedrichshain-Berlin, reproduced from his book, *Die Technik der Blutgruppenuntersuchung*, by permission of the Julius Springer Verlag.

Such a condition is known technically as multiple allelomorphism and is common if not universal. The differences between the effects of two of these allelomorphs may be so slight as to be scarcely distinguishable; yet wholly constant. This explanation may account for many variations in a trait that are customarily explained as due to modifying genes.

Details have not been worked out fully in many human cases, but in some of the animals and plants that lend themselves to experimental breeding as many as 10 or 12 allelomorphs of a single gene have been identified. In human heredity such cases as skin color and hair color, where many different grades of intensity are found in the same trait, may be interpreted in this way, an original gene having not one but a number of alternatives, each one producing a slightly different level of coloration.

Whether the fetus is harmed by having a blood grouping different from, hence "incompatible" with, that of its mother has been widely discussed. There appears to be no good evidence for the supposition. Many attempts have been made to connect preponderance of some particular blood group with a particular disease, but all the associations are slight, and there is so much room for racial differences and unconscious selection of the material that no conclusions can be taken as established.

Evidence is already coming to light that in the four blood groups there are sub-groups characteristic of individual families; and there are also other agglutinable substances in the blood, seemingly quite independent of those responsible for the classical "I, II, III, and IV" (209). One of these appears to be inherited as a simple Mendelian dominant: it is somewhat more frequent among Negroes than among whites.

Of the inherited abnormalities in the blood (320), I shall take space here to discuss only hemophilia. This is a failure of the blood to form clots in the usual way. The result is that, once bleeding is started, there is nothing to stop it, and the patient may bleed to death as the result of having a tooth pulled or of being punched on the nose. Even with the greatest precautions, a majority of those affected do not live to maturity.

In a general way, the tendency to this uncontrollable bleeding is inherited like color blindness (see p. 55); it is transmitted by the females and shown by the males. The gene is evidently in the female sex-chromosome—such at least is the ordinary case. Here as elsewhere it is always possible that inheritance may follow some other course, if the gene is transferred, or arises anew, in some other chromosome.

Hemophilia is so regularly sex-linked, however, that it has been a disputed question whether there is any case on record of a woman who was herself a bleeder. There have been numerous cases of women in hemophiliac families, who bled in various ways, but it is always possible to suppose that these were due to some other cause, especially as the bleeding reported in these cases is often from the uterus.

If there are women who carry a single gene for hemophilia and are also bleeders themselves, it is evident, as one might expect, that dominance of the normal is incomplete, and that a single dose may produce some results, though not so pronouncedly as a double dose which a man receives (221).

On the other hand, there should be some women who get the gene for hemophilia from each side—a double dose which should make them pronounced bleeders. Since such cases are at least rare enough to have made many writers think they do not exist, it is a question whether there is not an abnormal scarcity of them.

If so, a pair of these genes in the female sex is probably fatal—a baby with such a combination can not develop; therefore all living females who are bleeders must have only a single gene of the pair. Data are not yet sufficiently abundant and precise to determine this question definitely; but the suggestion just made is in accord with what might well be expected. It can scarcely be doubted that the same is true of many other serious abnormalities. Any one who lives to exhibit them has a single dose of them only, for a double dose prevents the fetus from surviving. This very likely applies to such defects as dwarfism, and to various crippling conditions. Inheritance from one parent injures the offspring; inheritance from both parents kills it.

Each family has its own particular type of hemophilia, as of other diseases, due to the presence of modifying genes in the germ-plasm (330).

Due to intermarriages, hemophilia has become concentrated in certain localities, as southern Germany and Switzerland. It occurs in at least one of the former royal families, that of Hesse-Darmstadt. Irene of Hesse, who married Prince Henry of Prussia, (brother of the latest kaiser), carried the gene and their three sons were hemophiliac. Alice, sister of Irene, married Nicholas II, the latest czar of all the Russias, and the little czarevitch was a hemophiliac, who nearly bled to death on at least two occasions. The hold of the monk Rasputin on the czarina was largely due to his supposed ability to check this issue. A story, typical of the finest tradition of diplomacy, is that Prince Bismarck knew of this trait in the Hessian family and encouraged the marriage of Alice with the czar as a matter of policy, with a view to crippling the sovereign line of a rival! Through Ena Victoria, who married Alfonso XIII of Spain, the gene was carried into this branch of royalty. Their oldest son, the Prince of the Asturias, heir to the crown, is a bleeder, as is at least one of their other sons—a fact that has given the Spaniards great concern as to the succession to the throne.

There are various inherited conditions that resemble hemophilia without being the real thing. Thus in one family the coagulation of the blood is normal but the bleeding time extremely long (387). In other cases there is a marked occurrence of nosebleed in a family (210). This is probably due to weakness of the membranes and blood vessels rather than to an alteration of the chemistry of the blood as in hemophilia.

High blood pressure is not a characteristic of the blood, but mainly of the arteries; however, it may be considered conveniently in this chapter. It is common among civilized people, and it tends to run in families.

According to the ordinary idea, it is favored by many of the minor vices of civilization: living at high speed, use of tobacco,

alcohol, and coffee; eating too much meat, habitual constipation. But the mummies of the old Egyptians show beyond question that it was common among them, although they were free from most of the vices just mentioned and must in large part have lived just the sort of life that the physician now recommends to a patient who is beginning to show signs of hardening of the arteries. Hence it appears that the difficulty can not be accounted for merely by supposing that people live not wisely but too well.

Climate plays a part, white men living in the tropics having a blood pressure 10 or 15 points lower than those in more northern climates. Race also plays a part, the Chinese for instance having a lower blood pressure than the whites.

Some of the family histories are striking. In one (323), both parents died at the age of 45 from the bursting of blood vessels in the brain. Of their 10 children, now all adult, only two, aged 33 and 35 respectively, have normal blood pressure, and these two may go higher in later life. The other eight have high blood pressure, and in four of them it is above 200 (220, 240, 240, and 290 respectively).

If it be supposed that this is because they were brought up in the same family, under the same conditions of life, one must yet admit that the blood pressure develops more under adult conditions than in those of infancy; and that middle-aged brothers and sisters who have long since left home and are living in different parts of the country, married to different kinds of people, are not living under much more uniform environment than are white adults in general.

Babies start out with a low and somewhat equal blood pressure in the two sexes, which rises slowly with age and makes a spurt at puberty (361); but among young men a blood pressure over 140 mm., which may be considered unduly high, is eight or 10 times as common as among young women. Normal, married women suffer relatively little from high blood pressure during the childbearing age; but if they have inherited a tendency in this direction, it begins to appear quickly after the menopause. On the other

hand single women, and women who are sexually abnormal in one way or another, are much more prone to high blood pressure at all ages (4).

One can scarcely resist the conclusion, then, that such factors as diet, tobacco, and the like, important as they are in individual cases, are yet secondary, and that the primary cause is constitutional. It appears that some sort of condition which produces thickened, brittle arteries, is inherited; this may be due to or accompanied by inadequacy of the kidneys, inability of the body to make proper use of its proteins, and the like (245). Probably the causes are somewhat different in each family.

In men there is nothing to prevent the manifestation of this condition: indeed, the secretions of the internal glands may favor it. In women, it seems as if the normal secretions of the ovaries and other internal glands prevent this tendency from manifesting itself, and it can appear only after these secretions diminish, following the menopause; but if these secretions are abnormal, the woman may show it at any age.

While tabulations showing that a trait runs in families (253, 396) are ordinarily not to be taken as proving heredity, for they may be explicable in some entirely different way; yet a consideration of all the facts leads to the conclusion that in this case the studies of families with high blood pressure, and those in which apoplexy is frequent, are of importance as pointing to a constitutional and inherited factor.

Similarly low blood pressure runs in families, and is probably hereditary for the same reasons. In one case (122) three brothers, two sisters, and a son-and-nephew had readings of 102, 96, 108, 94, 98, and 98 respectively. They were all in excellent health and came of a long-lived family.

An unusual tendency to blush is a well known family trait, connected with delicate adjustment of the capillary arteries in the skin and depending on the whole emotional equipment. Idiots do not blush at all; neither do infants, the capacity appearing at the age of two or three years if an inherited tendency exists. It is

a peculiarly human acquirement. "Man," said Mark Twain, "is the only animal that blushes—or needs to."

Varicose veins show a strong hereditary factor; and there are such family peculiarities as the Hashimi vein, which the prophet Muhammad had from his great-grandfather of that name. It was a vein (or artery?) on the forehead, which swelled prominently when he was angry. His father and grandfather were marked in the same way, so the peculiarity was apparently a simple Mendelian dominant.

CHAPTER X

GROWTH

If one tries to arrange a nursery full of babies in some orderly fashion, the attempt is at once found to be difficult. The inherited influences responsible for development are so diverse that no two children grow alike. The differences in these factors are seen most clearly when well-marked classes are compared—boys with girls, for instance; white children with black or yellow children.

Never after birth does the infant grow with as great velocity as before, although there is another spurt at adolescence. He grows more, in proportion to his initial weight, during the first year than in any subsequent year of his life. Since his growth is, on the whole, slowing down during his entire life outside the uterus, Charles Sedgwick Minot stated the paradox that the human being has seen his best days before he is born, and is already declining into old age (slowly, to be sure!) by the time he makes his stage entrance.

At birth and for some time afterward, the infant continues to grow by adding to the number of cells in his body. Starting as a single cell, he has increased many million fold by the time he sees daylight. But still he has made only one-twentieth of his growth, and he increases by volume three times during his first year in the open air.

Within a few years the number of cells tends to become fixed, and the great growth in size up to maturity is made merely by the enlargement of individual cells and the growth of substances between the cells. That there is plenty of room for growth in this manner will be admitted when it is remembered that the ostrich egg is merely a single cell, enormously swollen by the inclusion of stored-up food material.

It has been the fashion in many circles lately to talk of certain things occurring "in accordance with the law of normal organic

growth." There is no such law, as concerns the child as a whole. Growth occurs in one manner at one time, in another a few years later.

In general, every child grows by spurts or, as a gardener would say, by flushes. The body will develop rapidly for a time, then slow down a little while the legs grow vigorously for a few months; then these enter on a slower period as the trunk or neck takes up the impulse. Even parts of a limb grow at different rates: thus the bones of the leg may elongate faster than the muscles can keep up with them, and the stretching of the latter gives rise to one type of growing pains.

There is, in general, no close relation between physical and mental development (124), until one gets to the extremes. The very bright child is likely to talk before he can walk, whereas the very dull child walks before he talks. Precocity of talking is therefore an indication of good mentality.

It is difficult to get exact information on this point because family memories are none too reliable, and people do not understand the same thing by the words "began to talk." Merely saying "papa" is not enough, and special students have taken the ability to speak several words, or even short sentences, as the criterion. By these standards the bright children of California (367) were mostly saying several words by the end of the first year, and short sentences six months later. However, the range was large; some were reported as saying several words as early as five or six months, while several others did not do so until past two years of age. Parents therefore need not be alarmed if their children are slower than the average in talking. Little Torquato Tasso is said to have begun conversation at the age of six months. One need only allude to the much-vaunted linguistic precocity of Job, who cursed the day that he was born: he was nothing to Minerva, who appeared in the world with all her mental faculties fully developed. How the relatives must have dreaded a visit from Jupiter, armed with such an inexhaustible supply of cute sayings of his motherless little darling!

The bright children of California took their first steps at about 13 months, for the most part—only a month or so after they began to say a few words. The earliest reported was seven months, and here again a few did not walk until after 24. Two-thirds of a group of normal French children were reported to have walked between 11 and 14 months. There is a slight relation between early walking and intelligence, but it is impossible to predict anything from it.

Seven different methods of crawling have been described, but it would be almost correct to say that every child has his own method, and about half of all children are said not to crawl at all prior to walking. It is sometimes averred that crawling tends to delay walking, as the child becomes so accustomed to crawling and so well satisfied with his progress that he lacks the stimulus to rise on his legs. This is probably not correct: the tendency to walk is inborn and comes to expression at the predetermined age.

A case in point is that of identical twin boys (382). They took their first steps alone, without any encouragement, on the same day, when they were 12 months old. But Jacques had been crawling fluently for three months, while Henri had never crawled an inch, although he had learned to walk around upright while holding to furniture.

The most interesting of the methods of locomotion that precede walking is that of running on all-fours like an animal. While this is rare among white children, it is by no means as uncommon as has often been supposed (179). It is easier for a child than for his parents, because the child's legs are shorter in proportion to his trunk, and probably any child could be taught to get around in this way; his failure to do so is mainly the result of failure to see others do it, and some teaching of other methods. The tendency is therefore universal, and does not seem to run pronouncedly in certain families—at least, no cases have been reported where more than one child in a family traveled in this style. There seems to be no association with sex.

This is the manner in which the "wolf children" of fable get

about with their four-footed friends. Such cases have been reported from early antiquity, and there has always been some doubt as to their authenticity, in spite of Rudyard Kipling's account of just how it happens. A description has been given recently (355) of two children in Bengal, who seem to be better authenticated than most such. These girls, aged apparently about eight and two respectively, had been seen several times in the jungle and were finally dug out of a den of wolves and adopted by native Christian missionaries. The younger one died; the older was living at latest accounts, but had not yet assimilated all the blessings of civilization. It was a long time before she would eat in any way except by mouthing her food; and clothes evoked no feminine reaction from her. The children had run about only on all fours, and while the oldest is now said to have been taught to walk upright, she is still unable to do so gracefully.

To return to the subject of differences in growth, similar results may be due to different causes. Some dwarfs are small because they cease growth at an early age; others are small at birth and always grow slowly. A different process, governed by different genes, is at work in each case.

An old view regards the embryo as merely a miniature adult, the child as "a little man." It is supposed that it grows—nothing more. It took centuries for the most intelligent students to get away from this view, and the least intelligent have not yet outgrown it. But more accurate observation shows that the child is, in some ways, almost as different from the adult as the embryo is from the child. Each is really a different organism, undergoing continual development and change, dropping one characteristic to take on another.

By the end of the first year, initial differences have been pretty well masked through the operation of impulses that come into action later. Thus if a child is heavy at birth, it is not possible to prophesy with much confidence that he will be any heavier on his first birthday than is some other child born on the same day and several pounds lighter at the start. The size at birth may be



FIG. 17. A CHILD WHO GOES ON ALL FOURS

This infant in Central Australia has adopted, for the time being, the manner of locomotion of most other mammals. But such a trait is not characteristic of primitive peoples; it seems to be found just as often among the most civilized. It is not due to family inheritance, but to the remote ancestral inheritance of the whole human race. Photograph (by Herbert Basedow) from the *American Journal of Physical Anthropology*.

a family characteristic, as exemplified by a farmer's wife known to me who has borne five children, each of whom weighed from 12 to 16 lbs. at birth. As adults, all are rather slow, dull, and unambitious, and one is an epileptic imbecile.

In six years after birth, the height has ordinarily doubled and the weight increased four times. Boys and girls grow in a sort of race, one now passing the other, then being overtaken and passed in turn by the opposite sex. Growth in height is somewhat more uniform than growth in weight, but the great growth-spurt of adolescence usually begins in weight before it does in height.

This hasty summary is intended merely to emphasize a few points:

1. Boys grow differently from girls in all respects; hence they should not be given the same kinds of work, physical training, directed play, and the like.

2. The body does not grow as a whole, but in small parts and in different ways; hence there is ground for suspecting that growth is due to the action of a large number of different genes. Since these genes act in connection with the glands of internal secretion, one would expect to find many other differences connected with the differences in growth. It has been asserted, for instance (393) that persons whose legs are shorter than the trunk are more likely to be fully normal sexually than are those whose legs are longer. And the tall, slender type of build is more liable to one group of diseases, the short, thickset type to another (see Chapter XIX). Different temperaments also tend to go with different body builds, as popular opinion recognizes in distinguishing between the good-natured fat man and Yon Cassius with his lean and hungry look (see Chapter XX).

It goes almost without saying that slender parents tend to produce slender children, just as tall parents, short parents, and fat parents tend to reproduce their like. In matings of dissimilar types, say a man of tall, slender stock with a woman of short, stout ancestry, the children will tend to be intermediate and variable (75, 224). There is some evidence that shortness is largely

due to the presence of genes which stop the growth processes. One will go a long time before he finds healthy stout children produced by two thin parents. But among the progeny of two stout parents, one will find not a few thin children. The thin parent, then, appears to be a double recessive; the stout one may be a double dominant or the hybrid.

Extensive breeding experiments with small mammals have furnished some definite evidence in regard to the genes governing growth, which probably holds good in a general way for man. A majority of the genes identifiable in this connection affect the body as a whole, and it is an easy assumption that one of the ways in which this is brought about is by the influence of some of the ductless glands, particularly the thyroid, the pituitary, and the testicles or ovaries.

There is also definite evidence, however, of the existence of genes which act separately on individual parts of the body, as the legs, the trunk, or the head and neck (411).

The maturity of various traits at adolescence furnishes a good opportunity to see what the respective parts of the genes and the internal glands are. The rôle of the latter is customarily exaggerated by those who are not well informed as to the facts of heredity. To speak of the age of puberty as if it were a general maturity of body and mind is wholly misleading. Even if the word is taken in its narrowest sense, to indicate the appearance of body hair, this does not all appear at the same time. That of the pubes grows earlier than does that of the armpits. More broadly, it will be found that each trait of body or mind has its own period of development.

Hence it can not be supposed that any particular internal secretion—that of the testicles or ovaries, for instance,—brings about this development. The development is along lines laid down by the original genes; the internal secretions (which are, eventually, also the products of the genes) merely permit these different developments to take place at the appointed time. This is true not only of the details of development of the reproductive system

at puberty, but of all the traits of mind and body that undergo a change at this age (34). In short, the internal glands are secondary, the genes primary. Even though all the genes are present in the fertilized egg cell from the start, they do not all come into action at the same time; or at least they do not come into visible action at the same time. One may affect the infant, another the adult, so far as their recognizable results go.

Cases are known in which there are duplicate genes that seem to have independently the same effect. It was suggested earlier that the large number of chromosomes, 48, in man points to a doubling, perhaps repeated several times, of an original smaller number. If this is true, then the presence of duplicate genes would be expected: they would be merely the results of doubling. But as they will be quite independent in transmission, the study of heredity is somewhat complicated by them.

Ordinarily, however, genes are not thus duplicates, but have different effects. They may be complementary, neither one producing any observable result unless in the presence of the other—just like the two halves of a Seidlitz powder. They may be cumulative, piling up additional amounts of the same effect, just as a cake containing two teaspoonfuls of baking powder will rise higher than one which contains only a single teaspoonful. More frequently, the final result is produced by the contributions of many different genes acting in different ways. A character that is made up of as many elements as body build doubtless includes all of these kinds of activity.

It is sometimes supposed that fatness is due merely to laziness and gluttony. Of course these indulgences cause many people with a tendency toward fatness to become fatter; but many a thin person can testify from personal experience that they are not the root of the trouble. In a family which is given to fatness, the inherited constitution is a sufficient explanation. Due to the way in which the internal machinery is put together, the food intake is handled in an economical manner, leaving a surplus over the needs of the body; and there is a failure of the usual methods of burning up this surplus. In the thin family, on the

contrary, the engine is unusually wasteful of fuel and operates at low efficiency.

Women normally carry more fat than men because of their lower basal metabolism, that is, the rate at which fuel is burned in the body. This is governed by the interaction of the glands of internal secretion, the nervous system, the muscles, and many other parts of the body; of course it is not the same in any two persons, but in the white female sex as a whole it averages about 7 percent to 10 percent lower than in the male sex. Some races, the Chinese for instance, have a lower average basal metabolism than the whites, and the tendency to carry a thin layer of fat under the skin that characterizes white females is a conspicuous characteristic of Chinese males, as it is also of Negroes. Maya Indians, on the other hand, have a higher metabolism than the whites.

Within rather wide limits, neither diet nor poverty plays any part in limiting the growth of children. They grow as they are destined by their inheritance to grow. A British investigation (263) found that slum children grow just as well as the children of rural agricultural laborers. If the slum children are smaller—as in fact they are—it is because they come of smaller stock. The undersized and less muscular types have tended to concentrate in the cities; the burly, vigorous ones on the farms, for the labor of which they are better suited. Another investigation (249) found no relation between weight and height of children under five years and the fact of living in one- or two-roomed houses.

Little or no relation exists between the mother's health during pregnancy and the condition of her children—a fact developed in other careful studies (269). Indeed, only one factor was found which was related to the nutrition of the children, and this was not diet but maternal efficiency. The children of an efficient woman, or of "mothers who devote themselves to the care of their children and house" were definitely heavier and taller than the children of an indifferent mother.

The study of identical twins furnishes another method of determining to what extent the outside world influences growth. It is found that body and head form are moderately subject to such

influences, whereas the forms of ear, nose, and eye are remarkably constant in varying surroundings (386).

In other words, under what might be called standard conditions, the range of variability among children will be fairly constant. If these standard conditions are improved, the average of the population may also be raised, but the range of variability will not be decreased. In several countries, as Holland, Italy, Sweden, and the United States, the average height of boys of the present generation is notably greater—an inch or two greater—than that of a generation ago. Conditions of living have been improved in every way. In Great Britain there has been an increase in the more prosperous part of the population, but for the poorer class there seems to have been a decrease in some cases. Few will suppose that these changes represent changes in the genetic constitutions of the population in a single generation. They show a general increase of well-being, which has not made itself felt throughout the population of Great Britain to the extent that it has in the other four countries named.

Since body build, as made up of many different items of height and weight and conformation, is a family matter, and determined primarily by a widely varying set of inherited tendencies, it must be evident that attempts to judge of the health of school children and others by any standard of height or weight are essentially unscientific. Many a child has been called underweight, and his parents by inference accused of failure to care for him properly, when he was simply running true to form. The weight standard of health has no scientific basis, unless it refers to deviations so large that they can be noted at a glance, without reference to the scales, and still less to any printed set of alleged standards. Parents should be able to decide for themselves whether their children are normal for weight as compared with expectation from their ancestry. Slight variations of weight are usually of no significance; a sudden and marked change in the rate of growth is much more significant and demands prompt attention.

Generally speaking, it has been found that the child's adult build is predicted accurately, within reasonable limits, by his build be-

fore adolescence. It is only in exceptional cases that he undergoes a marked change after maturity. This fact is of some significance in vocational guidance,—for instance, a slender, delicate child is hardly destined to be a heavyweight wrestler, for his build when he reaches manhood will probably continue to be relatively slender and delicate (8).

Finally, in view of the great inherited differences in rate and amount of growth in all directions, it should be clear that any lumping together of children, as for education, on the basis merely of their calendar age, is thoroughly unscientific and pretty certain to be harmful to many if not to all of the group. The fact that a class of children is 10 years from birth does not tell the whole story. No two of them will have just the same mental age, as measured by relative intelligence; the same anatomical age, as measured by hardening of the bones, or appearance of the permanent teeth (46); the same pedagogical age, as measured by advancement in school; the same physiological age, as measured by approach to puberty; or the same emotional age, as measured by their adjustment to their surroundings and their attitude toward the world.

This fundamental fact of differentiation due to varied inheritances, which is so largely ignored in all training of children, is of far-reaching consequence in laying out the schooling of a child, directing his play, advising him on industrial work, studying his religious development, and guiding his social adjustment. In a group of 2,500 California women which I have studied recently, the onset of menstruation and therefore of physiological maturity ranged from the age of eight to the age of 20. It is obvious that any attempt to guide girls socially must go far astray, if it ignores the fact that one may be, in some important respects, as mature at eight as another at 20; or to take less extreme cases, that one in the fifth or sixth grade may be sexually as far advanced as one who is entering college.

The fact that every child is a unique individual has become familiar enough in recent years. It is still far from being acted upon. A study of heredity emphasizes it so forcibly that it should never again drop out of mind.

CHAPTER XI

ERRORS OF DEVELOPMENT

After the spermatozoön and ovum unite, the fertilized egg-cell which they form begins to grow with great speed, and within a few months the whole human being has been sketched in, so to speak. Due to the action of different genes, different parts of the embryo are stimulated to grow at different rates; special chemicals or organ-building substances are elaborated at various points; all these react on each other; and so on, by a process which is so complicated as to baffle complete analysis, the embryo grows to be a baby, always in accordance with a pattern which is laid down in the germ-cell through the interaction of the double set of genes received from father and mother respectively.

If the imagination be allowed to dwell a moment on the extraordinary complexity of this process of development; on the almost incredibly minute and delicate adjustments necessary to produce such a result as, say, a perfect eye, it will be clear enough that there are innumerable opportunities for a slip to occur, and for the final product to fall short of perfection.

Such an error of development may affect any part of the body whatsoever. If it be a serious one, and occur early in life, the result will be the death and expulsion of the fetus. If it be less serious, the result will merely be a baby who is not built quite according to specifications.

A complete catalog of these errors would be long and tedious, and would interest the medical man more than the parent. Here I shall only touch on a few of the commoner and more important; and I shall also leave for a future chapter all consideration of the many important errors in development that, in popular language, affect principally the mind. There is of course no logical basis for such a separation; mind and body are only different aspects of the same baby, and they can not possibly be separated in prac-

tice. Anything that affects the individual at all affects both "body" and "mind,"—though in differing degrees. But the distinction is a convenient one, since some classification of these errors is necessary to avoid a mere hodge-podge; I shall therefore do in this case as I have done in various other cases in this book, namely, follow the popular classification without at all intending to justify it. This chapter, then, will deal with bodily abnormalities, apart from those I have already mentioned casually in connection with other topics.

One of the most serious, and perhaps the commonest (though club-foot is a close second), is congenital dislocation of the hip. Any defect in the formation of the hip-bone or its socket may end in this, if strain in the uterus or at birth pushes the head of the hip out of place, but usually the defect is due to an under-development of the pelvis on one side, and does not manifest itself until some time after birth. In so far as heredity is involved, undoubtedly a number of recessive genes working together are required to produce the anomaly, hence it would not be expected that the trait would run in families in a conspicuous way; and in one American series, 88 percent of the affected individuals were found to have no affected ancestor in the three generations immediately preceding (238, 239).

On the other hand, in cases where one parent was affected nearly one-fourth of the children were affected.

The abnormality is six or eight times as common in girls as in boys (316). One might guess at first sight, therefore, that one of its genes is carried in the female sex-chromosome. Such a conclusion would be rash. The fact is that the female hip is normally not so well made as that of the male, that is, it does not fit so closely. Hence the same strain applied to two babies of opposite sexes will throw that of the girl out of place more quickly than that of the boy. Apart from this particular defect, the subjects are usually well-built, bright children.

Other anomalies may affect the entire skeleton. In the conspicuous cases of dwarfs (10) and giants, certain of the internal

glands have either been overstimulated and allowed to work unchecked during development, or else have not done their fair share, with the result that growth has been too small or too great. There are different forms of dwarfism and it seems likely that in many instances, at least, they represent a defect that is fatal if it comes from both sides of the ancestry. In other words, a single gene for dwarfism may produce a dwarf; a pair of the genes would produce nothing, for the egg-cell which received it could not develop to maturity.

One may also be a giant in spots. This partial gigantism may amount to anything from a single overgrown finger up to a derangement of a large part of the skeleton, and while it may sometimes be due to the fact that a series of cell-divisions runs wild during development, it often runs in families so that the trouble must rather be ascribed to the original genes. Here is a man, one of whose legs is an inch and a half longer than the other. His father showed the same peculiarity (6). A still different type is represented by an overgrowth of a complete half of the body, so that the subject resembles an individual put together from two halves, one of which did not match the other. This is interpreted as the first stage in a line that leads to the production of identical twins (127). One half of the embryo, at an early period, started to grow somewhat independently, but not enough to break loose and set up in life for itself.

The peculiarities of parts of the skeleton are almost innumerable. Knock-knees and bowlegs are both common, and to some extent inherited, although they may be due also to rickets, bad training, and the like. The marriage of a man with knock-knees and a woman with bow-legs would by no means be expected to produce, by compromise, straight-limbed children; rather it would tend to produce some children with knock-knees and others with bow-legs. In short, such traits are independent in inheritance, and usually do not influence each other or cancel each other out.

Spinal curvature (scoliosis) is often ascribed to rickets, also, and this disease is often present. But why, when a family has rickets,

does it result only in curvature of the spine, and fail to manifest itself in the legs, for instance? One can only assume that the manifestation is determined by the genes. More than two-thirds of all cases of spinal curvature are to the left, and most of the cases of primary right-sided scoliosis are said to be in families marked by a high frequency of left-handedness.

Defects of the extremities are still more common, and so numerous that several scores of them have been catalogued. Among these are short fingers, of which eight or 10 different varieties are described. The family reported by W. C. Farabee in 1905 is generally credited with being the first case of Mendelian inheritance demonstrated in man. The arms and legs are short in this family, but the sitting height is nearly normal; and affected persons are stouter than their normal relatives.

Stiff fingers are also inherited in a pronounced way. An affected family which has been studied is descended directly from John Talbot, first earl of Shrewsbury, who figures in *Henry VI* and was killed in battle near Bordeaux in 1453. In 1874 his tomb was opened for repairs and his skeleton examined. The stiffness of the fingers was unmistakable (89).

People who have one of these peculiarities are not necessarily related to each other, for it appears that such errors in development may be caused by a variety of minute changes in the germ-plasm, and that they are occurring rather frequently. For this reason the gene is different in different families, and behaves in a different way. Apparently it may appear in any one of a number of different chromosomes, if not in all. To illustrate: web-fingers are markedly inherited, the connection being oftenest between the third and fourth fingers and, in that case, almost always between the second and third toes. Most frequently, the gene behaves as a simple dominant. But there are also well-ascertained cases in which it is sex-linked, others in which it is a simple recessive.

There is a family history in which this peculiarity is inherited only from father to son, never to or through a daughter. Just as some traits are passed from mother to daughter because their

genes are in the female (X) sex-chromosome, so it is natural to suppose that webbed toes in this instance are limited to fathers and sons, because their genes are in the male (Y) sex-chromosome (45).

Such traits are rare, for the Y-chromosome, both in man and in other animals, is so nearly devoid of recognizable genes that for a long time it was held to be a blank, which played its purpose in balancing up the chromosomes but did not carry any genes. Perhaps at least part of it actually is blank.

A plausible explanation of this condition is derived from the fact that it has no complementary mate, as have all the other chromosomes. It pairs with the X, which is unlike it, and the genes of one therefore can not be mates of the genes of the other, as is the case with chromosomes in general. If an unfavorable mutation occurred in the Y, there would be nothing in the X to mask or offset it, hence it would produce an effect at once, and if the effect were unfavorable, as it would usually be, the carrier of it would be penalized. Through millions of years the continuance of this process would gradually lead to the elimination of all Y-chromosomes except those which had the smallest possible number of genes, for the fewer the genes in this case, the less likelihood that they would be a handicap to their host.

There is at least one other human case which can be interpreted in the same way, though the evidence is not so full. This is a pronounced warty skin which appeared, apparently as a dominant mutation, in one Edward Lambert, "the porcupine man," of the 18th century, and was traced through three generations following (125).

Many of the common human abnormalities such as webbed fingers and split fingers also occur widely among lower animals, showing that they represent a general tendency in the germ-plasm—or in other words that a similar result in development may be produced by a slight change in genes as far removed as those of a man and a lizard.

In the infant, the soles of the feet are turned inward toward each

other,—a position well adapted to climbing trees, and presumably useful to his remote ancestors. In perhaps one child in a thousand, the feet fail to develop and turn outward in the normal way. The result is club-foot. In about one-half of the cases, both feet are thus affected. The defect is about twice as common in boys as in girls.

In from one-half to three-fourths of all cases, the abnormality seems to be due to heredity. In other cases it may be due to a faulty position in the uterus or even, it has been supposed in the past, to such an error as the wearing of tight corsets by the mother. But as it occurs less frequently in twin than in single births, there is no reason to suppose it is due to crowding. In so far as it is due to a peculiar shape of the uterus, such peculiarity is likely to be inherited, thus increasing the percentage of cases which must be charged to heredity. In matings of an affected with a normal person, 11 percent of the offspring were found to be affected—a percentage more than 100 times as great as is found among normal persons (104).

The explanation of all sorts of congenital deformities as due to conditions in the uterus has been carried far beyond the point of plausibility. Excessive pressure of the uterus (due perhaps to a lack of the normal amount of fluid around the fetus), tight membranes, pressure of bands of membrane, pressure of the navel cord, pressure brought about by the presence of tumors—such factors are invoked with great assurance, and were already invoked by Hippocrates, to account for the existence of abnormalities that appear at birth. Rare cases are known where the hands or feet, for instance, were amputated in the uterus by the cutting of a band of membrane, but in general these extraneous factors can not be held responsible, because (1) they are present in plenty of instances where a normal child is born, (2) most of the errors of development take their start during the first 40 of 50 days of life of the embryo, when these external factors would not make themselves felt.

In many families club-foot seems to be associated with other physical, and still more with mental, defects. An outstanding in-

stance is the poet, Lord Byron, who not only had a club-foot but came of an ancestry marked by a great deal of mental disease,—and showed it. In such families, if not in all, club-foot is probably due to a defect of the nervous system.

Flatfoot also seems largely to be inherited, although it is only brought to light by long standing. Army surgeons found it six times as common among Jewish as among non-Jewish soldiers of the English Army.

Deformities of the toes, popularly thought to be due to wearing tight shoes, are often wholly hereditary. This is the case with the great toe that is turned out of position (*hallux valgus*) and still more with the little toe, the development of which often starts at a normal rate in the embryo but gradually slows down until by maturity the other toes have left it behind in a rudimentary condition.

A rare anomaly, but one that is conspicuous when it exists, is extra mammae. In the remote ancestors of man, there was undoubtedly a line of nipples on each side of the body, to alimnt the litter of offspring, and these have gradually disappeared except for the single pair that remains and has increased greatly in size. But occasionally the ancestral tendency crops out, producing extra nipples that may be perfect enough to produce milk, and which are usually disposed along the abdomen in the old ancestral line. It is a striking illustration of the conservative tendency of the germ-plasm. Here is a character coming back that has been absent for no one knows how long—perhaps a hundred million years. A slight change in some gene is sufficient to call it into existence again, almost as perfect as it was when the dinosaurs roamed the earth.

In other instances the organ-building substances seem to be diverted into the wrong channel, so that a functional breast may be formed in some extraordinary location, as on the thigh or buttock. This tendency is inherited—it was traced through four generations in several instances (151), and may even be transmitted through the father rather than the mother, although it is usually expressed

in the mother. Still, the inheritance of extra and functional nipples in the male is by no means unknown (105). The classical illustration, if tradition is credible, is Anne Boleyn, queen of Henry VIII of England. She not only had extra nipples but also a double set of teeth and 24 fingers and toes. Whether she transmitted her reproductive peculiarities to Elizabeth is unknown. There has always been a certain amount of mystery about the virginity of the Virgin Queen, although only those will believe the story that she was really a changeling—and a red-headed country boy by birth—who also believe the story said to have been printed in the *Dublin Register* in 1782 that George Washington's childlessness was due to the fact that he was really female!

The presence of extra fingers or toes (polydactylism) is not rare, the number of persons so affected in the United States having been estimated as high as one in 1,000. There are unlimited variations of the trait, but the general basis is the splitting of the rudiment of one finger or toe,—or sometimes more than one (287). It is irregularly dominant in most instances. A Spanish family of seven persons is described, who totaled 164 fingers, one member having 23, another 21, and the remainder 12 fingers on each hand. A similar condition occasionally occurs in almost all animals, Julius Caesar's saddle horse being a classical example.

Brittle bones have already been mentioned in connection with deafness (p. 64). One boy who was born with both thighs broken suffered 12 other fractures before he was three years old. One man had had 106 fractures up to the time of last report. In such a family, ordinary twins may be born, one showing the defect, the other normal. Mere tension of muscles or weight of the body, as in dancing, may be sufficient to cause a fracture. This will probably be no surprise to those who do not approve of the modern styles of dancing; yet a fracture may also occur during such an inoffensive action as sitting down, or taking off one's hat to a feminine companion. Due to modifying genes, each family tends to have its own style of fractures; in one the brittleness was confined to the bones of the upper extremities.

Hernia is due to the existence of various orifices and sacs in the abdomen, some of which are normal in the fetus but should close during development. Often, however, they fail to close fully, and under the slightest strain, a loop of the intestines will protrude.

This is not "rupture." The latter term should designate a forcible breaking or pushing through between the layers of muscle that overlie the abdomen; but as a fact such a happening is rare and not easily produced even by intention. Hernia is distinctly a congenital, and ordinarily an inherited, condition (244). Fortunately, the closing of these openings is usually only delayed, not prevented altogether; and if the opening is protected by a truss for a few months or years, until it has time to finish its delayed development, it will give no further trouble.

In a series of 10,000 English recruits, 363 were found to be suffering from hernia. The proportion would have been higher among children, since most cases are cured before the individual is old enough to join the army.

Hernia is normally found in a little over 1 percent of swine. By three generations of selection and breeding, a herd was produced in which nearly half the males had inguinal hernia. Effects of environment were apparently slight. In this case a two-gene hypothesis was selected, according to which the double recessive produced hernia in the male, whereas a female of the same constitution was normal (391).

Hernia may follow an undescended testicle. In all mammals the testicles are formed in the abdomen, but in man and most others they descend gradually until by birth or within a year afterward they have gone down into the scrotum. But in most boy babies the muscles attached to them are so active that they frequently pull the testicles back out of the scrotum into the inguinal ring; and the inexperienced mother who feels the empty scrotum at once thinks her son is defective.

If the testicles can be pushed down into the scrotum, they are normal. Sometimes they are retained so strongly that they can not be pushed down; this is abnormal (cryptorchidism), and if it

continues through childhood must be remedied by an operation before puberty, otherwise the glands may atrophy. At least one adult in 500 is said to have an undescended testicle, and this failure of development runs markedly in families. A striking illustration is furnished by a Russian and his wife, both physically normal, who had six boys and two girls (55). In every one of the boys, either one testicle or both failed to descend. One girl is apparently normal but the other, aged 15, has never menstruated and shows distinctly masculine characteristics. It is impossible to say whether the gene produces an effect on both sexes in this case, but it might well do so.

In the early development of the fetus the face is formed by bringing flaps around and uniting them in front—to describe the process very crudely. The result is that there are lines of weakness here which continually manifest themselves in errors of development. Sometimes the union may be too tight, and the pinching prevents the development of some of the teeth (p. 76). Or the union may be incomplete, resulting in hare-lip and its more extreme form, cleft palate (239). The various degrees of these errors tend to run in families, though in particular cases they may be sporadic and accidental (228). Hare-lip occurs on the left side four times out of five. There is no sex difference.

A minor manifestation is the protruding mouth or prognathism which is found so markedly in many of the royal families of Europe and which, thanks to their love of having their pictures made, can be traced back for many centuries. It is common among other animals (286).

This peculiarity is usually known as the Habsburg lip, because of its prominence in Austrian royalty, and it can be traced back as far as any portraits of the sovereigns are to be had, namely to the thirteenth century. The portraits of these earlier sovereigns were made in later days from tradition, and therefore may not be good likenesses; but the lip is unmistakeable enough in an authentic medallion representing Frederick III and his son Maximilian (born 1459).

The latter married Mary of Burgundy, who had inherited the same type of face from the Valois. It can be traced back with confidence farther in France than in Austria, and with less confidence to St. Louis the Crusader (born in 1215). It is an open question, then, whether it might not better be called a French lip than an Austrian lip. The marriage above mentioned served to fix it, and cousin marriages since then have perpetuated and spread



FIG. 18. THE EARLY HABSBURG LIP

Frederick III (1415–1493) and (at the right) his son Maximilian I (1459–1519), two of the early Habsburg emperors of Germany. Both show the Habsburg lip, but the son has it in a particularly pronounced form, which no court artist who valued his life would have portrayed on him if it did not exist. Besides, even at the age of 10 Maximilian could not articulate plainly because of the configuration of his mouth. From a contemporary portrait.

it (84). It varies greatly in degree, and there is a tendency toward deformity of the whole skull—a high forehead, protruding eyes, and changes in the shape of the nose. But the heavy lower lip is rarely wanting (117).

Unimportant as is this trait from any practical point of view, it is an admirable example of the constancy with which a slight peculiarity can be handed down inescapably from parent to off-

spring, generation after generation—in this case for at least five or six hundred years, and no one knows how much longer.

This particular trait happens to be dominant (as are thick lips generally (107)), and hence particularly conspicuous. A recessive trait will be passed along in the same way, reappearing perhaps less often but equally in evidence on the proper occasion.

Since identical twins are due to an error in development, the familiar subject of twinning may be conveniently mentioned here.

Ordinary twins are simply ordinary children born two at a time, and resulting from the fertilization of two different egg-cells at about the same period. In some cases the mother produces two eggs simultaneously; in others a second egg may possibly follow the first one within a few days. Such twins resemble each other no more closely than do ordinary brothers and sisters. They may be of the same sex or of different sexes. There are a number of interesting cases on record where they even have different fathers, a white woman, for instance, bearing twins one of which was white and the other mulatto.

In two or three out of every 10 cases, however, the twins are produced from a single egg, presumably through the appearance of two growing points instead of one, at some time after fertilization. Being, then, merely parts of the same person, such identical or one-egg twins resemble each other with extraordinary closeness, and they are the ones which give rise to bewildering mistakes. But as this duplication of growing points may occur at various times, there is still room here for a slight amount of variability, depending on the length of time between fertilization and the commencement of growth in two places.

Twins are more likely to be girls than they are boys; triplets and quadruplets much more so (199). This may be due to the more frequent death of male twins as embryos.

Twins are born once in 80 or 90 pregnancies but the number of families in which they are a possibility is greater than this for twins, like lightning, do not often strike twice in the same place. Only about once in 20 times, it is said, will a woman who has borne a pair of ordinary twins bear a second pair of them.



FIG. 19. THE ONLY LIVING AMERICAN QUADRUPLETS

These four daughters of Mr. and Mrs. F. M. Keys, of Hollis, Okla., were born on July 4, 1915, and were 12 years old when this photograph was taken during a vacation in California. The same girls as babies are shown in *Applied Eugenics*. There is a previous history of twinning on the father's side, but none on the mother's; she had borne four children before these. Leota (here shown at the extreme left, followed by Mona, Roberta, and Mary) has blue eyes, the others brown. The girls weighed about 4 pounds each at birth and were all nursed by their mother. Photograph from the *Los Angeles Times*.

It has been calculated (65) that 15 percent of all mothers have the twinning tendency, and that in any given pregnancy, the chance that one of these mothers will actually produce twins is one in 10. All these figures are to be taken only as rough approximations, at most.

If there is a family history of twins, it is usually found in both sides of the mother's ancestry, being recessive.

The tendency to produce ordinary twins is related to the wife's age, increasing steadily up to a maximum at 35 or 40 years, after which it declines. The probability of a twin pregnancy is three or four times greater in a mother of 37 than in a mother of 22. The number of preceding births seems to exercise little influence (65).

CHAPTER XII

LEFTHANDEDNESS

Of the innumerable deviations from the normal bilateral symmetry of the human body, one of the best known is righthandedness. The predominance of one hand is based on the predominance of one hemisphere of the brain. In righthanded persons the left hemisphere is larger and more fully developed—so much so that by mere inspection of the skull an expert can tell with a good deal of confidence whether the subject was right- or left-handed. Not the skull alone is affected, but the whole skeleton, the righthanded person also having the right leg longer and stronger in most instances.

The predominance of one side extends to a number of functions—perhaps to all, if the facts were known minutely. Handedness is associated to some extent with eyedness, one who is righthanded usually using the right eye to sight with. The righthanded and eyed person will also most frequently place the right thumb above the left, when the hands are clasped; and perhaps tends also to place the right arm on top when the arms are folded in front of the chest.

In more complex movements, involving both hands or both sides of the body, many complications are found, as for example in the use of a golf stick or shovel. If the manuality is named by the hand which is nearest the business end of the instrument so that a man who places the left hand at the small end of a baseball bat and the right hand above it, nearer the middle, is called righthanded, then it will be found that the majority of white people use broom or shovel lefthandedly and bat righthanded. The hand used on the spade is an almost infallible determiner of the foot which will be used on the same implement.

It has been declared that a bodily balance is the highest state, in which the individual uses the right hand singly, but the left hand in batting or sweeping, this being supposed to produce, or be the

outcome of, a more symmetrical body development. In any case, the situation last-named is found most frequently among superior males while the commoner situation, in which the individual bats righthanded but sweeps lefthanded, is more common among inferior males, and among females, whether they be superior or inferior. Evidently, then, there is not only a difference associated with intelligence in the male sex, but a consistent sex difference which, in the female, does not seem to be affected by differences of intelligence (85). Correspondingly, more superior men than women are right-eyed. It is worth noting, in passing, that in winking a person unconsciously tends to wink the weaker eye.

Several investigations have agreed in showing two or three times as many lefthanded individuals among intellectually subnormal persons as among mentally normal; and lefthanded girls are more common than lefthanded boys among defectives, while the reverse is true among the intellectually superior. This tendency seems to be graded roughly in accordance with the degree of mental deficiency. As one goes down in the scale of Intelligence Quotients,¹ the superiority of the right over the left hand, as shown by gripping

¹ The intellectual level is customarily measured by standard tests such as the Binet, and then expressed as a single figure, the Intelligence Quotient or much-cited IQ. This is the ratio of mental age (as determined by tests) to chronological age. Thus a 10-year old child who passes only the tests that an average five-year-old can pass has a mental age of five years and, in comparison with his chronological age of 10 years, an IQ of 50. The 12-year-old who is mentally on a level with the nine-year-olds has only three-fourths of the amount of intellect that he should have at his age, hence an IQ of 75. The child who is up to the standard of his age is normal, with an IQ of 100, while the superior child of eight may be doing the work of a 10- or 12-year-old and have an IQ of 125 or 150, as the case may be. For adults 16 has been taken as the age beyond which there is no development of the inborn intellect, and adult intelligence quotients have been figured on that base, though there is now a tendency to make the base a couple of years lower. As a fact, the level of intellect continues to increase slightly, in bright people at least, through the period of adolescence, but probably not after the age of 20 or 21. Thenceforth increase in intellect is not vertical but horizontal; knowledge increases, the power to deal with that knowledge increases through experience; but the fundamental capacities of the mind seem not to increase, and with old age they begin to decrease.

tests, decreases, or is even upset by a stronger left hand (135); in other words, the relative strength of the left hand increases with decreasing intellect. This tendency is of course open to many notable exceptions.

Among some extreme lefthanders the natural method of writing seems to be from right to left ("mirror writing"). Leonardo da Vinci's notebooks are a familiar illustration. It has been asserted that any child will naturally move one hand in one direction, the other in the opposite; but there seems to be no foundation for this belief.

Asymmetry is a peculiarity that seems to have arisen late in evolution, and to be largely limited to mankind. Lower animals normally do not show this predominance of one or other hemisphere of the brain, with the resulting predominance of the opposite side of the body.

In the monkeys, the first signs of this appear. Some of them are quite ambidextrous (ambilateral would be a more exact term); others are markedly right- or lefthanded. In the anthropoid apes, although the hemispheres of the brain are approximately symmetrical in appearance, the bones of the right arm are usually longer than those of the left in the gibbon and orang, as in man, while in the chimpanzee and gorilla the left arm is superior; and with this difference there goes a tendency to use one arm or the other, not so pronounced as in man yet quite different from the ambidexterity of most mammals. *Pithecanthropus* was lefthanded (353).

That handedness is not a matter of custom and teaching, but an inborn peculiarity, seems to follow from the facts that have been presented and others like them. If handedness is largely inborn, any attempt to change it later in life is likely to be disastrous. This is now almost universally agreed. Children who are born lefthanded and forced to shift to the right are supposed to become nervous and to stutter. In the present state of knowledge, the child should be left alone, to use whichever hand nature intended him to use.

The whole question of stuttering is still obscure. It is plausibly supposed that the dominant half of the brain contains the speech center, and that in cases where this dominance has not been thoroughly established, or where it is changed due to a forced change of handedness, the speech center is also disturbed. Stuttering tends to run in families, but whether this represents inheritance of a nervous defect, or merely bad example, has been disputed.

Various censuses of school children indicate that from two to three per cent are stutterers, and the peculiarity is at least five or six times as common among boys as among girls. This fits perfectly with the idea of a hereditary basis, for as pointed out elsewhere the male is expected to show more disturbances of all kinds than does the female.

The most critical evidence produced thus far is from the study of identical twins (348). In most instances, if one is a stutterer, both are; but four cases are reported of such twins, one of whom was right-, the other lefthanded, and in these cases only the latter stuttered. In a fifth case, both had stuttered, but the lefthanded one more pronouncedly than the right.

The evidence indicates that stuttering is a manifestation of a nervous system that is not in good working order, and that this defect is inborn, probably inheritable. While the exact nature of the association with lefthandedness is not clear, there seems to be more than a chance relationship.

There have been a few cases in which an individual was obliged to move both hands or arms in the same direction at the same time, the ordinary independence of the two sides of the body being limited. In one of these (88), if the boy held a pencil in each hand and wrote with the right hand, the left would produce a mirror image of the same words, and acute pain was caused if an attempt was made to move one hand while the other was held. If one hand was touched, the sensation was felt in both hands, but most keenly in the one not touched; and sensations were crossed, so that if a hot object was held in the right hand and a cold one in the left, the right hand felt coldness and the left hand hotness. This

disturbance was transmitted through four generations, involving nine individuals, and seemed to be a Mendelian dominant. It brings to mind the Siamese twins,² who were incompletely separated halves of the same boy. It is related of them that if one was touched while asleep, the other would awake and ask what was wanted.

The idea frequently advanced, that the use of one hand is merely a consequence of the use of one eye in preference to the other, not only begs the question but has no evidence in its favor. Besides, it is asserted that among the congenitally blind, the percentage of lefthanders is the same as among those who see.

If lefthandedness is inborn, one might also suppose it to be inherited. This has been the general supposition, but the case is so involved that some have even doubted whether heredity figures at all. Such an attitude is extreme: the association of handedness with definitely inherited differences such as length of bones, size of brain, sex, degree of intelligence, and finger-print patterns, speaks for its own inheritance as well. On the other hand, the complexity of the situation presented in the preceding sentence is sufficient evidence that the inheritance is not simple and well defined, as some writers have made it appear.

Lefthandedness sometimes accompanies a much more far-reaching asymmetry, namely, the complete reversal of the viscera, known in medical literature as *situs inversus*. In such cases the heart, for example, is found on the right side and the appendix on the left side of the body. The whole (sometimes only a part) of the contents of the body are turned around as in a mirror image.

² Chang and Eng, born in Siam about 1812, were brought to New York about 1832 and exhibited by a Mr. Bunker, whose name they adopted; but they will always be known to posterity merely as "the Siamese twins." About 1840, in a visit to the mountain region of southwestern Virginia, they met twin sisters, in one of whom Eng became much interested. When he decided to marry Sally, the logical thing seemed to be for Chang also to marry Adelaide. But the entrance of romance sowed the seeds of jealousy between the Bunkers, so that thenceforth the quartet led a somewhat tumultuous life on their farm near Mt. Airy, N. C. In spite of this, each raised a family, and they prospered in the tobacco industry until their death in 1874.

This condition also runs in families, so has been presumed to be inherited, and in at least one case (372) acted like a simple recessive. It is also found in most "Siamese" twins, and in them the righthand component is usually the one reversed. How far it exists in normal one-egg twins has not yet been determined, as it can be diagnosed with accuracy only by X-ray photographs. Lefthandedness sometimes gives a clue to it; a more dependable sign is the position of the testicles. In the ordinary male the left testicle hangs lower than the right; in *situs inversus* the right hangs lower. Transposition of the viscera probably does not occur oftener than one in 5,000 or 10,000 individuals.

CHAPTER XIII

DISEASES OF THE BODY

From an evolutionary point of view, people are adapted to live under certain conditions, and as long as they remain within the accustomed surroundings and do not undergo any marked change in body or mind, they are well. A change in either the individual or the surroundings, or in both, may push the individual near to the limit of his adjustability: in that case he may be called sick. If he is pushed farther, he becomes unable to adapt himself, and dies (217). After nearly 2300 years, it is difficult to improve on the definition which Aristotle gave in his *Categories*: "Men are called healthy in virtue of the inborn capacity of successful resistance to those injurious influences that may ordinarily arise; unhealthy in virtue of a lack of that capacity."

There is thus no hard and fast line between sickness and health. Nor is there any absolute adaptation. It is relative to the surroundings. The pickaninny on the Congo and the Fuegian baby at Cape Horn are adapted each to its own home, and therefore in good health; if they were exchanged, or if either had the temperature adaptations of the other, he would be a sick baby.

Again, common usage has agreed implicitly that it is not the individual's own welfare, but that of the species, which is at stake in the adjustment to surroundings; and any failure to recognize this fact results in confusion. Thus a woman may be incapacitated in the hospital, by childbirth, but she is not considered to be sick, for the process is useful to the race, therefore normal, even though it may be in some cases injurious to her as an individual. A woman frequently describes the discomfort attending menstruation by saying that she is "unwell," but it is universally recognized that this is a euphemism, and that the very use of the term "monthly sickness" means that she is not sick, but is going through a perfectly normal experience which she prefers not to describe more definitely.

On the other hand, sterility might in special cases be helpful to the individual; but being in general harmful to the species it is an abnormality or, broadly, a disease.

From these general considerations it follows that the individual boy or girl, with his or her inherited make-up, is always a factor in disease; broadly speaking, it is not too much to say that disease always involves the hereditary factor. The individuality,—the constitution,—modifies the course and gives its particular character even to the disease which apparently owes the least to heredity.

This is just as true in a disease like diphtheria, which depends on the invasion of the body by a specific enemy, as it is of some gross error of development. It is particularly true of the common infectious diseases of childhood. A child may escape them if he is born to escape them; if he is not, the best of parental care will be unavailing and when he starts to school, and is exposed to infection, he can hardly remain unscathed. Malnutrition has no relation to infection with such diseases—scarlet fever, measles, diphtheria, mumps, chickenpox, smallpox (165). If a child escapes them, it shows that he is immune from birth, or else has not been exposed; it is no particular recommendation of his parents' efforts.

While the "germ theory of disease" is now impregnable, it is sometimes forgotten that germs are only half the story. They must have something to work on. As a fact, almost every healthy individual has in his body at all times the germs of a score of deadly diseases. They are not deadly in his case, merely because his bodily resistance is not overcome; and this depends to some extent on his manner of life, to a greater extent on the nature of his body, as it developed from the ancestral germ plasm.

Hence the physician does not cure—a fact recognized at least as long ago as the time of Hippocrates. All that the physician can do is to assist the individual, either directly as by quinine, which strengthens the regulatory efforts of the body in its fight with a definite invader, namely, the plasmodium of malaria; or indirectly, as by administering nourishing food, ordering rest, giving hot or cold baths. He can also, of course, alter the structure of the body

to some extent, as by surgery, or help to reduce the enemies of the body, as by killing the mosquitoes in a given district; but for clear thinking it is necessary always to bear in mind the important point, that it is the individual who, in the last analysis, must work out his own salvation; and his ability to do so depends primarily on the equipment which has come to him through his ancestors.

In the case of germ diseases the body usually has, or in favorable circumstances can acquire, a resistance or immunity. An immunity which is the result of recovery from attack can not be inherited but, if the mother possesses such, it may pass to the fetus from her blood, and in this case will be lost only gradually after birth. This result is rarer than has sometimes been thought, as the evidence indicates that the protective substances in the mother's blood do not pass freely through the placenta. There is ordinarily a marked difference between her blood and that of the fetus in this respect.

If an infant seems to be immune to, say, measles, in the early months of life, there are four possible ways in which this immunity may have arisen:

1. True inheritance through the germ-plasm.
2. By receiving protective substances from the mother's blood, through the placenta.
3. By receiving the same substances while nursing, from the mother's milk.
4. By developing its own protection, perhaps as the result of a light and unrecognized infection.

Experiments (250) show that No. 2 does not play much of a part, No. 3 in some cases still less. It is impossible to say what is the relative importance of Nos. 1 and 4, but they are to a large extent aspects of the same fact, since an infant can not develop immunity unless he possesses in his constitution the capacity to do so. Immunity, then, depends much more on the child's own inheritance and growth than on any temporary loan from the mother.

On the other hand, there are cases in which even two or three

attacks of measles do not confer the customary immunity on a child. Evidently the child lacks something, constitutionally, which is necessary to build up the usual immunity.

The use of the Schick test has shown that there are marked familial differences in immunity to diphtheria (166). Italian children in the United States show little susceptibility, Negroes much (417).

In scarlet fever, as shown by the Dick test, children from the same family have in general the same degree of susceptibility (166). American Indian children are notably immune (343). Country children are found to be more susceptible than city children, but this merely points to the greater prevalence of infection in the crowded city, and the greater likelihood of early, light attacks which confer subsequent immunity. On the whole, boys seem to be more immune than are girls.

The reverse is the case in most diseases—boys seem to be rather weaker and more susceptible than girls, a result easily explained by the presence in the boy of the unlike sex chromosomes, X and Y (301). Any unfavorable gene in X will tend to make its influence felt, because there is nothing to mask it; while in the girl, with the two X's, an unfavorable gene in one may be balanced by a favorable gene in the other. Hence the male sex is in almost every way the weaker, having a higher death-rate before birth and ever afterward (301).

When a disease is found to attack women more than men, the explanation is usually rather easy to see. Some of the diseases of old age, such as cancer, heart disease, and apoplexy, are most frequent among women, but this is precisely because the women, being the more resistant sex, live to a greater average age and therefore there are more of them to be attacked by these maladies of advanced years. Gout is an exception: its greater prevalence in elderly men may be due to their earlier intemperance in food and drink.

In other cases the influence of the glandular system, and particularly the sexual glands, is to be sought. Women suffer more

from diseases associated with the thyroid gland, goiter for instance; this gland is closely connected with the female reproductive system and is put under a strain by pregnancy. Probably if the facts were fully known, some of the now unexplainable cases would yield to the same type of explanation: thus whooping cough and St. Vitus dance (chorea) are commoner among girls than boys.

Occasionally a sex difference in the frequency of a disease may be explained merely as the result of a difference in occupation, training, or habits of the sexes; but when it is an outcome of the sexual constitution, as is most often the case, it is primarily a matter of inheritance.

The fact that a disease is described as depending on heredity does not necessarily mean that it is any less curable. The cretin may be restored by iodine; even such an abnormality as a sixth finger can be "cured" by the surgeon's knife; and with the progress of medical science there is every reason to suppose that even the most refractory cases such as hemophilia will be brought under control. But the hereditary factor means that no matter what is done to the individual, the original tendency will be passed on to his posterity,—a fact of less importance to the individual but of great importance eugenically to the race.

While the conclusion is inescapable, that inheritance plays a fundamental part in virtually all disease, there have been some cases in which this conclusion has been particularly attacked. Tuberculosis is a conspicuous one. A couple of generations ago, few persons doubted that consumption was "inherited." With an increase in the understanding of heredity, it became clear that a germ disease, as such, could not possibly be inherited; then some writers missed the point altogether, by forgetting that the soil in which the seed grows is certainly inherited, and they began to deny any importance to heredity in connection with this malady. The swing away from the constitutional idea of tuberculosis came after 1882 when Robert Koch discovered the bacillus—although he himself, in his first announcement, took pains to emphasize the importance of inherited differences.

Autopsies have shown that virtually every one—at least, virtually every city dweller,—becomes infected with tuberculosis in childhood. The germs are on all sides, and few can hope to avoid them. But in the great majority of cases the system resists this infection, walling it off in the lungs where it produces so little effect that the person never knows he has it.

On the other hand, some do succumb to it. Many attempts have been made to measure the relations between this lack of resistance, and the serious course of the infection.

It is universally found that those who succumb to tuberculosis have many more tuberculous relatives than do those who resist the infection. But closeness of contact does not explain this wholly, for children of a tuberculous mother are no more likely to fall victims to the white plague than are children of a tuberculous father, although they are much more closely associated with the mother in daily life (294). On the other hand, there is little tendency toward infection from husband to wife or wife to husband, although these two live for years in much more intimate association than do parent and children (111).

Again, in three-fourths of 317 tuberculous families studied, including 1013 persons, the disease appeared at the same point, or on the same side, of the lungs,—a clear suggestion that there is a common weakness based on a common descent (91, 380).

The racial distribution of tuberculosis also suggests plainly the importance of the factor of inheritance. Negroes, for instance, are far more susceptible than whites; and mulattoes stand half way between the two races in this respect, as they do in many others. The American Indians,—indeed, all the native inhabitants of the western hemisphere,—are notably susceptible to consumption. It was not known in this part of the world until Columbus brought it; consequently the natives had never been exposed to infection and resistant strains had not been produced by the elimination of the less resistant, as has been the case for thousands of years in Europe (282). The inference is that the American stocks must have separated from those of Europe at an early period, before the germs of tuberculosis became widespread.

The European Jews, crowded for centuries in Ghettoes where infection was easy, have developed a high resistance to tuberculosis. The Jews of Yaman, in southern Arabia, have not had this opportunity. When the latter came to Palestine and were brought into contact with tuberculosis, they showed a low resistance to it (203).

All such facts, and innumerable others that might be added, point to the importance of the factor of inheritance, in resistance to tuberculosis. This is not merely a matter of general vigor and good health (though these play their part); for the American Indians were fine specimens of manhood and yet fell easy victims to the white plague. It is clear that there must be certain definite particulars in which an individual is born more or less predisposed to resist the invasion of this ubiquitous enemy. The shape of the body and the reactions of its tissues both doubtless are involved.

While it is impossible to conduct any experiments with human beings, some careful and suggestive ones have been carried out with guinea pigs (412). These showed definite and marked differences in resistance, in various inbred families. The heredity was responsible for more than 30 percent of the difference in susceptibility to tuberculosis; all characters of general vigor taken together did not account for more than 5 percent or 10 percent.

The two groups of factors—inherited resistance and general vigor—between them thus account for something like one-half of the total differences in mortality, leaving the other half to be accounted for by other factors of an incidental or accidental nature.

Similarly, in human families, there are large inherited differences of resistance to tuberculosis. Even the greatest resistance may be broken down by highly unfavorable conditions. On the other hand, in non-resistant families, particular care may enable an individual to survive when his brothers and sisters succumb. There is always hope. But even if the individual recovers from an infection, he will still transmit his own low resistance to his offspring.

The dependence of cancer on heredity has been even more strongly contested than the dependence of tuberculosis; yet the

facts seem to be clear. Not only cancers, but particular kinds of cancer, seem to run in families. Thus among the Bonapartes it was cancer of the stomach, from which Napoleon, his father, his brother Lucien, and two of his sisters, Pauline and Caroline, are all supposed to have died.

Cancer seems to start in a mutation of a single body cell. The change in the internal constitution of this cell destroys its class-solidarity, so to speak; it is no longer content to march along in the ranks, doing its appointed work in the body, but starts out on an independent career without regard to the interests of its fellow-workers. It multiplies with extraordinary rapidity, and soon forms a mass of independent cells which are parasitical in the body and usually end by destroying their host.

The original cause of this mutation appears to be irritation. A strong enough irritation, as from X-rays, will probably produce a mutation in some cell of any body; but the cells of some bodies are so constituted that they mutate under slight provocation: thus any one *may* get cancer; some people are almost sure to. The problem is again that which appears so regularly in these pages—the essential problem of heredity—the relationship between internal and external conditions, each of which is highly variable; the final result being due to the interaction of the two.

If there are always these two elements, resistance and irritation, there is little hope at present of changing the former, but some opportunity to change the latter. The fact that one has inherited a lack of resistance does not necessarily mean cancer. The genes may be offset or modified by other genes; or the resistance, fostered by biological living, may be great enough to overcome milder irritations.

On the other hand, because cancer is primarily an affection of old age, one must reach the paradoxical conclusion that the betterment of public health tends to increase the amount of cancer in a community, for persons who would otherwise have died early, of something else, before they were old enough to show cancer, are thus kept alive for cancer, the mortality of which is at its highest after 50.

The statistical evidence of inheritance of a susceptibility to cancer in man is universally regarded as untrustworthy, because so many persons who might later have shown cancer, die from other causes before they reach the cancer age. The most useful evidence is that derived from careful breeding experiments with lower animals. While these do not wholly solve the problem of what happens to man, it is hard to believe that the biologic laws governing the growth of cells can be so different in various species as to permit of radically different conditions.

Mice have been the favorite subject of these breeding experiments, and the number grown and inoculated in different laboratories runs far over 100,000, covering a quarter of a century and hundreds of mouse generations. No one questions that susceptibility behaves definitely, in some strains, as a recessive. By properly planned matings it can be passed through 20 or 30 generations, and then brought back to light at any desired moment by the mating of two individuals, each of which comes from a non-resistant strain. In other strains susceptibility seems to be dominant.

In short, whether an animal will produce cancer in response to irritation depends primarily on its inherited constitution. In the lack of a definite inheritance of susceptibility, nothing short of an overpowering and extraordinary irritation will suffice to produce a malignant growth. In the presence of this susceptibility, a commonplace irritation will provoke the disorder. The time of appearance of cancer is therefore largely determined by outside agencies; whether it will appear at all is largely dependent on whether the germ-plasm contains the possibility.

Even in diseases where one might at first sight think the constitutional element was absent, it may yet be shown to be important. Thus in one family (265) there are 13 children, each of whom had pneumonia at least once; seven of them died from it. In the father's family there was found to be a definite tendency toward constitutional inferiority of the lungs, which manifests itself chiefly in a breakdown from tuberculosis early in life. The mother's family does not show this tendency; on the other hand it shows a

strong liability to mild infections of bronchitis and pneumonia in childhood. The combination of these two forms of weakness produced children with extreme liability to and low resistance to any sort of infection of the lungs; hence 100 percent incidence of pneumonia in infancy and early childhood, with a death rate 25 times as high as the average.

Similarly, scurvy has been known to occur in one twin, while absent from the other who had been fed in the same way. Undoubtedly scurvy is due to lack of vitamins; but if the system is, from some constitutional derangement, unable to utilize the vitamins, then the factor of inheritance may be manifested.

The same situation is found in rickets, which has in late years been too easily assumed to be merely a matter of vitamins. Some families, with the best of care, develop this defect, others with no care at all do not. There is a case on record where a sound woman had rachitic children by a husband who was himself in childhood rachitic, while before and after she had sound children by non-rachitic husbands.

The case of goiter is analogous. This abnormal swelling of the thyroid gland is due to a lack of iodine in the body. In regions where there is not much iodine in the soil or water, goiter is endemic (Switzerland is the familiar illustration, but many interior parts of the United States, and also the Pacific Northwest, have more than their share). But even in these regions some families suffer more than others. The disease appears twice as often in both of a pair of twins when they are from one egg, as when they are from two eggs.

Sporadic goiter often acts like a simple Mendelian dominant, affecting the female vastly more than the male. Sometimes, however, it is associated with deaf-mutism, and in this case appears to be recessive, and shows no favoritism between the sexes (30). Although both due to affection of the thyroid, goiter and cretinism do not seem to go together in families in the United States to a marked extent. Cretinism, however, also affects the hearing, most cretins being more or less deaf-mute. It is evident that the func-

tion of the thyroid could be impaired by a variety of mistakes, during development, hence the variety and independence of inherited conditions.

Jaundice has been traced through five generations as a simple dominant, and diabetes insipidus (production of extraordinary amounts of urine) through six generations with similar conclusions.

Whether the commoner form of diabetes, which results in the presence of sugar in the urine, is so markedly inherited, is doubtful. During the last 50 years it has increased much more than any other disease in the United States, particularly among women, and this rapid increase in itself suggests that dietary habits may be largely responsible. Eating too much, and in particular too much starch and sugar, is largely to blame; and this is perhaps illuminative of the fact that the disease is common among Jews, rare among Negroes, and that it is closely associated with obesity and hardening of the arteries. Moreover, the amount of diabetes in Germany declined greatly during the war, when the population was on short rations.

Studies have been published (401) showing that diabetic patients have many more relatives affected with diabetes than do normal persons; but this might be interpreted as showing that in the same families, and even in the same social strata, there is a common tendency toward the same dietetic errors.

The immediate cause of diabetes is the disorganization of certain groups of cells, called the Islands of Langerhans, in the pancreas. This deranges the internal secretions so that the body does not dispose of carbohydrates effectively. Any inheritance that disabled these particular cells would result in a liability to diabetes; and any interference with the function of the kidneys would also play a part. The appearance of severe diabetes in young children shows that such disabilities may be congenital. Until more critical evidence is available, however, a large part of diabetes must be considered at least avoidable by common sense in diet and habits of living. The uncertainty of explanations depending too much on heredity is shown by the amount of accompanying speculation

as to why the disease is now dominant, now recessive; why it attacks the sexes equally in youth but the male more in old age, and the like.

In the case of a simple abnormality due to a single gene, there is of course no mystery about its being now dominant, now recessive, or about its appearing to result from any one of a number of quite different genes. One need merely think forward to the interaction of the genes in development. Hundreds of them are working together toward a common end, to which they all contribute. One which comes into action today will produce a certain effect in the development of some organ; but if it does not come into effect, because it is not there, nevertheless approximately the same disturbance may be produced by some quite different gene that comes into action at some other period in the development of this organ.

Hypersensitiveness assumes protean forms, from the idiosyncrasy of the person who can not eat some particular food, as fish, milk, eggs, beans, or walnuts, to that of large families, many of whose members suffer from asthma or hay fever, and other families in which the disorder is manifested as gout (220).

In the Medici family of Florence, gout is traced through 10 generations. While most of this family of typical extraverts were high livers, the affliction appeared just the same in those like Cosimo I, whose supper was a handful of almonds; in cardinal Leopoldo, whose stomach trouble enforced a simple diet; and in Cosimo III, whose puritanical ideas made good living as well as every other form of luxury hateful (276). Physicians have put the number of persons with some form of sensitization as high as 10 percent of the total population, and the number of actual sufferers from hay fever (severe forms of which are always likely to pass into asthma) as high as 1 percent. In addition to the forms of allergy mentioned are to be reckoned urticaria or the hives, a form of irritable nose or "cold in the head" (vasomotor rhinitis), some cases of migraine and of colitis, eczema, and angioneurotic edema. In every case the discomfort is produced by foreign proteins taken into the body. In a simple instance, such as sensitization against

strawberries, all the victim has to do is to avoid strawberries; but this rarely tells the whole story, for most persons who are sensitized at all are sensitized to a number of different things. Many of these things are almost ubiquitous, such as plant pollens and (in civilized society) orris root, the dried and powdered root of the iris which is a constituent of most face powders. Again, even though a man sensitized to horse proteins may keep away from horses, he can not be treated safely by serums in the case of diphtheria or pneumonia, for most serums used in medicine nowadays are horse serums.

The study (52) of many families marked by such diseases as hay fever and asthma (which often begins in babyhood) leaves little doubt that the tendency to sensitization is inherited, and is probably due to at least two genes. Its general aspect is dominant. In one family which showed a history of five generations of allergy, including altogether 94 persons, 56 percent of these were allergic, while of 23 unrelated persons, who married into this family and were therefore studied as controls, only one was thus hypersensitive (351).

A French family is reported in which sensitiveness to white of egg ran through four generations. Psychologists have brought to light cases in which a similar reaction to some food, in both parent and child, was due to imitation or early and unpleasant childhood experiences; and on this basis some have tended to deny the hereditary basis of all allergy. But the cases in which parent and child show the same reaction are the exceptions; the sensitization that is passed on in the germ-plasm is a generalized one showing constant variations in its manifestations, presumably due to modifying genes: thus one member of a family may be sensitive to cat, another to horse proteins; one to the pollen of ragweed, another to that of goldenrod.

To extend this chapter farther would be to invade the domain of medicine. My general conclusion is that the constitutional factor, conditioned by heredity, is rarely absent in disease, and that it must be sought even in diseases that seem to be most notably due

to other conditions. Appendicitis may result from an inherited peculiarity of formation of the intestines; similar peculiarities may produce a family in which constipation is, so to speak, hereditary (211); differences in immunity, based either on chemical differences, on peculiarities of bodily structure, or both, are always to be expected.

If disease is thought of in the proper light, as the reaction of the body to certain conditions, it will be clear enough that no two bodies can react in just the same way. The problem of disease is therefore quite as much a problem of human individuality as it is of germs.

CHAPTER XIV

INTELLIGENCE

Probably no observant parent doubts that a child inherits the peculiarities of his mind just as he does the peculiarities of his body.

The philosophers of a century or two ago, who formed their idea of human nature by shutting their eyes and using their reason, arrived at a different opinion.

"We are all born equal in intelligence and character; it is education alone that produces the differences," affirmed Claude Adrien Helvetius; "Any man, normally well endowed, can become a great man if he is properly educated."

John Locke wagged his head: "I imagine the minds of children are easily turned this way or that, as water itself."

It is easy to see from the last statement that the old bachelor had never brought up any children; and that he would have sympathized with Pierre Paul Royer-Collard, who declared solemnly, "I know nothing more despicable than a fact."

Such a view of human nature is dead, and will remain so, even though a few bold, bad Behaviorists dig up the bones and rattle them together to scare little psychologists. The evidence against it and in favor of the inheritance of differences in the basic equipment of the mind is abundant and along many different lines.

1. Wherever one looks, bright children are found to come, in general, from bright parents, not from dull, just as regularly brown-skinned children are found to come from brunettes, not from blondes (53).

This is true as a rule, I believe, in every investigation that has ever been reported. No son of an unskilled laborer has ever become an eminent man of science in the United States, and unskilled laborers have made remarkably few contributions to the ranks of genius in all history.

This has sometimes been ascribed to better educational advan-

tages or influence ("pull"). But the condition exists equally in childhood, as was shown by an investigation (367) of 1,000 unusually bright children in the California schools. On calculating a quota for each economic group, based on the size of this group in the whole population, it was found that unskilled laborers contributed only one-seventy-seventh of their quota to the number of gifted children, while the professional classes exceeded their quota by more than 1,000 percent.

The parents were not predominantly wealthy: the average income of the father was not much above the average income for the whole state, and the bulk of the children came from good, but not from "the best" neighborhoods. The parents, in other words, did not exceed conspicuously in wealth or in social position,—merely in brains. The number of eminent relatives of these gifted children was vastly in excess of the average.

In the occasional instance when the father of a gifted child occupies a humble position, it will be found usually that the occupations of his kinfolk are distinctly higher. In the California study, only one of the fathers was described as an unskilled laborer. This was a farmer, who had moved to Berkeley and taken whatever work he could get in order that his children might be able to attend the state university.

The mental superiority of these children was not due to exceptional educational opportunities. In the first place, California has an excellent and compulsory free public school system; every child has the same opportunity for education. In the second place, the superiority of these children, as measured by tests, bore no relation to the length of time they had been in school. They were superior from the cradle, because they came of superior ancestry.

They had inherited good brains, just as some other children unfortunately inherit poor brains.

The fact that the IQ and the educational achievement have little connection with the amount of time a boy or girl has spent in school has been demonstrated conclusively in a number of studies (82). If all the children of the same age, say 10 years, in a given com-

munity are considered, one finds an enormous variability in their school achievements. Perhaps 5 percent of this variability is due to differences in length of time they have spent in school. The rest of the differences are due mainly to differences in their inherited endowments—their capacity to make use of the instruction given them (152). It is significant that the percentage of differences in physical traits due to non-heritable causes is also 5 percent (108).

Moreover, these differences in the achievements of children from different social strata continue to manifest themselves even when the children are taken early from their own homes and placed in orphanages (186). Though the environment is now the same, those who came of better ancestry make more progress than those with worse ancestry.

2. Not only do children resemble their relatives in mental, as in physical characteristics, but they resemble them to just about the same degree. There is now an immense body of data available on this point, and all of it agrees, or the exceptions are due to causes that are evident.

If the child has eyes of the same color as his parent, or is tall like his parent, or has curly hair like his parent, no one supposes that this resemblance is due to home training or education. The amount of this resemblance can be measured and expressed in figures. When the resemblance in traits of the mind, also measured and expressed in figures, is found to be approximately the same, one can hardly avoid the suspicion that heredity is equally important in the two cases. It is unreasonable to suppose that a given degree of resemblance in the body is due to heredity, but the same degree of resemblance in the mind is due to something else; when underlying every trait, function, or activity of the mind there is a structure, function, or activity of the body.

If one is comparing two men, there is no difficulty in expressing the result. It is only necessary to say, for instance, that one is 2 percent taller than the other. But when dealing with groups, say 100 fathers and 100 sons, it is not so easy to tell the whole story in a single figure. To take the averages, and to say that the average

height of the sons is 2 percent greater than that of the fathers, may be wholly misleading, for it merely covers up the real differences instead of bringing them out. It might be found, for instance, that every son in the group was 2 percent taller than his father; or it might be found that the short fathers had tall sons and the tall fathers shorter sons; the sons as a group might nevertheless average 2 percent taller than their fathers, yet the real facts in the second instance would be radically different from those of the first instance.

The need for a more delicate instrument of analysis was met by mathematicians with the invention of the calculus of correlation. Somewhat complicated in practice, this is simple in principle. Two groups are compared, not as to their averages, but as to their deviations from their respective averages. This permits the deviation in each case to be measured in its own unit, so that inches can be compared with pounds, or number of breaths per minute with number of white corpuscles in the blood, or anything else; the units of the two groups need not be the same. Height of parents in inches may be compared with height of sons in inches; but height of parents in inches may be compared equally well with color of daughters' skins, if an arbitrary scale can be adopted to measure the precise difference between say a strawberry blonde and a peanut blonde.

The result of the process is expressed as a single figure, the coefficient of correlation, which varies between -1 and $+1$, depending on the degree of resemblance between the two groups. If the resemblance is perfect—if the pupil who is best in Latin is also best in algebra, and so on down the line, every pupil in the school holding exactly the same relative rank in the two classes—then the correlation is perfect and is expressed by $+1$. If the result is reversed, the pupil at the top of the Latin class being at the bottom of the algebra class, and so on through, then the correlation is equally perfect but negative, and is expressed by -1 . If there is no relation at all between standings in the two classes, the coefficient will be 0 . Ordinarily it is somewhere between 0 and $+1$ or -1 as the case may be, and is expressed as a decimal.

It is found that the intensity of resemblance between parent and offspring, due wholly to heredity, is .50; that is, any deviation from the mean in the class of parents will be matched by a deviation just one-half as great in a class of sons or daughters. Such findings, it must be remembered, are purely statistical: they describe what happens when a large group is measured, but they do not at all tell what must happen in the case of a single pair. If a whole group of fathers tend to exceed the average height of their race by six inches, then the group of their sons will tend to exceed the average height of the race by only .50 as much as the excess of their fathers, or three inches. The coefficient of correlation between height of father and height of son is therefore .50. The result will be the same if the fathers fall short of the average—the sons will fall only half as far short of the average, and will therefore be taller than their fathers.

If the coefficient of correlation for a given trait, as between parent and offspring, is found to be not .50, it is evident that one is not dealing with the influence of heredity alone, but that outside influences are at work, either to increase or to diminish the resemblances.

Thus the correlation between duration of life in father and duration of life in an adult son is found to be not .50, but only .13. Evidently—as one would of course expect—the son's longevity is not merely a matter of heredity. He is living a generation later than his father, and living conditions change in the meantime. He is subjected to different stresses of habit, occupation, diet, epidemics, and the like, all of which play a part in determining how long he shall live, so the biological resemblance is cut down.

In this case the environment has tended to make parent and child less alike. In other cases its tendency is to make them more alike. The resemblance between father and son in respect of occupation or profession is not .50 but .75, which can be explained plausibly by assuming that to the inborn resemblance of .50 the effect of influence and education has added another .25 in the direction of greater resemblance. In any trait which is part of the general culture of a group, one would not be surprised to find the correlation increased. Thus, to take an extreme illustration, if one were to

measure the resemblance between speaking English in the father and speaking English in the son, in the United States, the correlation would be not far from perfect. Whatever inherited physical structure and functional ability may underlie this use of language, the influence of education is imposed to produce a correlation nearly 1.00.

It is found both theoretically and by actual observation that the correlation for heredity is the same between brothers or sisters as between parent and child, namely .50. But in a study (376) of this point the resemblance between pairs of children from the same family in intellect was found to be .60. Evidently the influence of common culture has tended in this case to raise the correlation 10 points.

An understanding of the measurement of resemblance by correlation is necessary to an understanding of heredity. The modern knowledge of that subject, particularly as concerns mental traits, is largely dependent on it.

3. The child resembles relatives whom he has perhaps never seen, just about as strongly as he resembles those with whom he has been brought up, and who have had therefore every chance to influence him. This was shown particularly well in studies of European royalty (407). An individual was found to resemble, in mind and character, his maternal grandfather, who lived in some distant kingdom, just as closely as he did his paternal grandfather in whose court he was brought up.

Even in the production of American men of science, the maternal influence was found to be just as strong as the paternal, although the latter must have determined the economic and social status of the home (33).

In general, the child resembles the father, whom under urban conditions he may rarely see, just about as much as the mother, with whom he is associated all day long; and regardless of differences in the education of the two parents (137). This is true not only of the school child who is exposed to the whole range of culture outside the home, but to the infant, whose mother is almost his only

associate (137). It is equally true on the farm, where the boys from an early age are associated more with their fathers, the girls with their mothers. Despite this differentiation, there is no more evidence of the influence of the like sex, in the mental test ratings (187).

All this is inevitable if the child's traits are primarily determined by inheritance; it is incredible if these traits are merely the result of example and precept.

4. The segregation of mental traits in the same manner as physical traits also affords cogent evidence that they are inherited in the same way. Here is a family in which one child out of four has a certain mental peculiarity—a quick temper, or unusual ability in arithmetic, or whatever it may be. If this were an isolated case, any old explanation would do. But when it is found that exactly the same proportion appears in family after family, and in generation after generation, from a given type of mating; that a change in the constitution of one of the parents will produce a definite and predictable change in the ratios of the children; and that the proportions found are the same as those shown in similar matings by traits of the body whose heredity has never been questioned, it is asking too much to suppose that the reason in the two cases is of an entirely different order.

In specific traits the tendency seems to be toward alternative inheritance,—that is, if the parents are contrasted in a given trait, the child resembles one or the other of them. If this were ascribed to home training and the formation of early habits, it would be necessary to assume that one parent always determined completely the home environment; whereas the tendency in real life is for parents to work out a compromise in this matter. But the genes do not compromise in the same way.

5. Intellectual development despite seclusion offers a strong argument in favor of the inborn potentiality, as against the "clean slate" idea of the child mind. Such cases are naturally rare, and when found they are often vitiated by the fact that the stock is mentally abnormal; for normal people do not keep their children

immured. Occasionally, however, an instance comes to light that is significant.

Such a one is that of John Henry (112), who had practically no school training (he had barely learned to read); practically no contact with other children, and no home education save what he may have picked up for himself from a few religious books and a stray copy of a newspaper. He was kept indoors by an eccentric mother; half starved and wholly ill-treated. Yet when rescued at the age of 15, he tested up to age (1.04 on the point scale, 98 on the Binet). If his mental level was inborn, this is easily understood; if a product merely of opportunity, it is inconceivable.

The case of Gipsy Mary is similar. Stolen by Romany vagabonds at the age of four, she was never sent to school or given any formal education; yet when rescued at the age of 16 she was found by the customary mental tests to have an IQ of 100, and after 12 months of instruction was ready to enter high school.

6. Mental resemblances in orphans make an interesting study. Pairs of orphan brothers or sisters reared in a private family are no more closely alike than similar pairs reared in an orphan asylum. Those reared in the asylum are no more, and no less, alike (92) than ordinary pairs of brothers or sisters reared by their own parents (139). Finally, unrelated children reared in the same orphan asylum show no regular resemblance to each other (164). Although subjected to this common environment, they are no more alike than any two children picked up at random on the street, who have been brought up in wholly different surroundings. There is scarcely a conceivable explanation of these facts, except that brothers and sisters resemble each other mentally because of their inheritance.

7. Another aspect of the same facts is the failure of marked changes in the surroundings to modify the level of intelligence as measured by modern tests. I shall have occasion to refer to this several times in future chapters. Not only may an unfavorable home environment cause no measurable decrease in the IQ (188), but improvement in the environment may cause no increase.

This is true to a large extent even of profound internal changes.

Early puberty is one of the most far-reaching alterations that the body can undergo, yet it is not accompanied by early intellectual development. Here is a girl whose menstruation is fully and normally established before her fourth birthday. With it go the usual physical changes, such as enlargement of breasts and appearance of pubic hair. Although she is healthy, her intellectual development is not altered (126). Is it not evident that the latter is highly independent after the early days of embryonic life?

Malnutrition is a commoner type of influence that is often asserted to be a cause of mental retardation if not of mental defect. In the Los Angeles city schools three groups of about 25 children each were studied intensively for six months from this point of view. Two of the groups were selected because they were retarded (they were also undernourished); the third because of malnutrition, without regard to retardation. By special care, the physical condition of the children was much improved; their emotional attitude, willingness to coöperate, and responsiveness improved at the same time, as did their accomplishment in the classroom. But when the basal intelligence was tested, there had been no change whatever in the IQ, apart from the slight variations always found in a retest: there were as many who showed a decrease as an increase. The facts which have often been misinterpreted are brought out in their proper relations by this study (406). Improving the physical condition of children may enable them to make more effective efforts; it is richly worth while on every account; but it will not change their levels of intellect.

This aspect of the whole problem has been illumined recently by two particularly careful studies on foster children, one in Illinois (115), and the other in California (40). These were concerned particularly to find how far the child's general intelligence could be brought up by good surroundings.

Both of them, incidentally, support the view now widely accepted, that many peculiarities of behavior and conduct are more subject to influence from outside than are traits of intellect or physique (311). They represent social much more than biological aspects of life.

The California study is particularly interesting in dealing only with children placed as babies—all of them under one year of age and most of them at about three months. It therefore had an ideal opportunity to measure the total effect of environment acting after birth. It appears from this study that all of the factors of home environment taken together account for something like 17 percent of the differences in intelligence among children. The total contribution of heredity seemed to be about 75 percent or 80 percent. The small remainder must be assigned to the sort of chance and accidental influences that are always present in development and have been mentioned many times in the course of this book.

Of the influence assigned to heredity (75 or 80 percent), 33 percent was allotted to the parents. The rest belongs to the more remote ancestry. Often, of course, the influence of the parents is thought of, and properly so, as including also that of all their progenitors; but if one is making a separate study of the various influences that account for the differences in IQ among children, it is legitimate to attempt to apportion the responsibility in more detail, as in this instance.

This study also gave an almost unique opportunity to determine how much an IQ could be changed by the greatest possible improvement or impairment of the environment, acting from birth onward. The conclusion was reached that in such extreme conditions, it might be altered as much as 20 points; but that such extreme conditions would not be reached in more than a home or two in a thousand. Rough as the present methods of measuring mental traits are, then, they do succeed to a useful degree in getting at the real innate intelligence of a child; and 70 percent of the average run of school children have an actual IQ within six to nine points of that represented by their innate intelligence—that is, any changes in the ordinary conditions of life would not change the IQ more than six to nine points.

8. If mental resemblance is due to training, pairs of ordinary brothers and sisters, nearly of the same age, should be about as much alike as are identical twins. Everyone knows that they are not.

9. If mental resemblance is due to training, pairs of brothers or sisters should be more alike at 15 than at five, since there have been 10 years during which they were subjected to the moulding influences of family and social life. But the passage of this period of time and the influence of these forces do not make them any more or any less alike in fundamental traits that can be measured accurately.

10. In unlike twins, traits subject to much training should show greater differences than those subject to little training. They do not.

11. When children are given a task which none of them has ever attempted, and are trained in it regularly for an equal length of time, it would seem that all should make the same progress, if training is the only thing that counts. They do not. All make some progress, but those who were best at the beginning are even farther ahead at the end of the period of training. In other words, some have a greater capacity to improve than do others. The provision of equal opportunities for all does not make men equal in achievement—it simply increases the relative differences that existed previously; it makes them more unlike than they were before.

This is true of experiments carried on under carefully regulated conditions, at least so far as concerns many complex or difficult tasks (possibly it is not true of some of the more elemental functions of the mind. There is discrepancy among experiments on this point (275)). Unfortunately, it is not true of the public schools. Here the children are more alike scholastically at the age of say 15 than they were at five. This is because the brighter ones have been held back while the teacher gave an undue amount of her attention to pushing the laggards along. As at present organized, the public schools are a forcing influence for the dull, a stunting influence for the bright (302); so that, as has been well said, "The bright pupil is the retarded pupil."

12. That intelligence is largely independent of schooling was shown on a large scale by the army mental tests (414) where nearly two million men were measured (296).

These various facts, and these various aspects of the same facts, all point the same way. If half of them were invalidated the remainder would still, it seems to me, offer proof that, under the ordinary circumstances to which children are subject, the differences in their mental endowments, and even in their mental achievements, are due overwhelmingly—perhaps as much as 90 percent or in some cases (193) 97 percent—to their inborn and inherited peculiarities.

The seventeenth century doctrine which regarded the child mind as a blank sheet of paper on which parent, teacher, and pastor might write whatever they chose, is merely a relic.

If anyone insists on appealing to literary figures of speech, the child mind might be likened not to a white piece of paper, but to an exposed kodak film, blank in appearance but actually containing the potentialities which, given the customary treatment, will reveal an immense wealth of detail.

Proper care in the process will bring out these details in all their sharpness. On the other hand, an ignoramus or bungler can spoil the film in this process,—can smudge or blur or fog it, by injudicious zeal. But the whole process is so standardized, and the film is so well adapted to the standard treatment, that, developed in a thousand different photographic studios, it would show only slight differences in result.

However, figures of speech are not the proper mode of analysis of biological phenomena. In this case, the facts are on all sides, and the facts speak for themselves.

CHAPTER XV

DIFFERENT KINDS OF INTELLIGENCE

It is one of the standing jokes of psychology, that no two students have ever agreed as to what "intelligence" really means. Different purposes make different definitions useful; but if it is taken here to indicate, more or less accurately, the ability of a child to adapt himself to changes in his surroundings,—to get along in the world,—in such a way as to favor the progressive evolution of the race, then it is at once evident that this may, under different circumstances, call for rather different types of ability.

From this point of view it would be possible to split "intelligence" up into an indefinitely large number of special abilities or capacities; but for convenience it is sometimes well to keep the number as low as possible. A threefold division has often been used for practical purposes, in which it is recognized that a child's specialization may be either verbal, manual, or social.

1. Intelligence may be abstract, dealing with symbols. The type specimen is perhaps such a man as Isaac Newton or, to take a more recent example, Albert Einstein. Since letters and words are merely symbols, the abstract type of intelligence (expressed as the IQ) is the one with which the customary mental tests are largely concerned, and it is called "general intelligence." This is reasonable enough, since it is the possession of language, and the ability to think in its abstract terms, that sets man off from the lower animals more conspicuously than any other one thing. Its inheritance is discussed in the preceding and succeeding chapters.

2. On the other hand, ability may be more concrete and mechanical, as is seen in thousands of boys who are miserable in the dry routine of the schoolroom, but perfectly happy if given something which employs their hands or brings into use the large muscular groups of the body. If the occupation, in addition, gives a sense of achievement and power, compensating for the feeling of inferiority



FIG. 20. EMILY AND SOME OF HER ACCOMPLISHMENTS

This 18-year-old girl at Letchworth Village, New York, with a mental age of 4 years 10 months, which classifies her as a low imbecile, has been able, after proper teaching, to make the articles shown. Even idiots have been found capable of a good deal of useful work, when their interest was aroused; and by it their conduct has been greatly improved, without any change in their IQ's, however. Those with mental ages as low as 2 years are taught such work as sewing carpet rags. Lack of the abstract intellect does not doom an individual to a life of idleness or crime. Photograph from Dr. George J. Veith in *Proceedings* of the 51st annual session of the American Association for the Study of the Feeble-minded.

which the boy has when he attempts to deal with abstract ideas at school, he is fixed for life. These factors help to explain why many morons become truck drivers.

Of course, mechanical ability is not in opposition to the more abstract type of "general intelligence." The boy who really surpasses in it will not be found lacking in wit. But the two types of intelligence correlate (359) to the extent of not more than .40.

It can be shown mathematically that the amount of variation of one factor, that is determined by the other factor in the case, is measured by the square of the coefficient of correlation, which in this case would be .16. Thus it appears that general intelligence accounts for only one-sixth, at the most, of a youth's mechanical abilities; five-sixths of the latter are independent of the more abstract types of mental processes.

This permits a certain amount of effective mechanical aptitude in those whose general intelligence is too low to be of much social use. Low-grade idiots, persons who have no more than the general intelligence of a three-year-old child have been taught, when their interest was aroused, to do such work as bookbinding, knitting sweaters, or hooking rugs.

The situation is illuminated even more plainly by actual tests of success in learning trades in an industrial school (56). Office work—which is not mechanical at all—was the only type of employment, out of 22 different ones studied, that showed a high correlation (.98) with general intelligence. The correlation between the IQ and success in the other occupations was small, and was negative in just about as many instances as it was positive.

Other studies (233) indicate that industrial efficiency is associated with the level of intellect up to a mental age of about 8 years, but that above this age there is no relation between the two. Since persons below the age of 8 are largely idiots and imbeciles, or at least the lowest types of moron, who in many cases require life-long institutional care, it appears that most of the mental defectives who have intelligence to keep out of custody have at least a chance to get along in the industrial world; and of the children who are put in the

public school classes for defectives, one-half or more will make their own way satisfactorily in adult life (314).

The fact that a boy is found wanting in tests of more abstract intelligence therefore does not condemn him to a life of idleness or crime, nor even doom him to be a career man in the garbage department. If he has mechanical ability, he may succeed in a wide variety of industrial occupations, under proper supervision; and while he will not rise to the top of his profession, he should be self-supporting, productive, and contented.

Such men as Thomas A. Edison and Ernst Werner von Siemens are the ones usually cited to illustrate this type of intelligence, but they are not representative, falling much more nearly in class 1. They have little in common with the farm boy who can not get through English grammar, but who can take his tractor apart and put it together again in the course of an afternoon, without the slightest hesitation.

The problem may be approached from the other side by inquiring as to the mechanical aptitudes of children who excel in so-called general intelligence. The gifted children studied in California (367) excelled the average greatly in abstract abilities, but very slightly in manual work; while in mechanical ingenuity they actually fell below the average of the schools. This may have been due partly to a lack of interest, and an overspecialization along abstract lines; but it illustrates the fact that high degrees of both types of ability do not necessarily go together, although they do so in many conspicuous instances.

The inheritance of mechanical abilities has been insufficiently studied. In junior high school boys, such abilities have been found to be largely independent of the economic status of the home, or even of such factors as the number of tools owned by the father. It is a reasonable surmise, therefore, that the basis of these abilities is inherited, and is not dependent merely on training or imitation (5).

3. The third type of ability, which is perhaps of greater importance to a child in getting through the world pleasantly and profitably than either of the other two, is the social. This is the talent of being able to deal with people; it is seen in a high degree in such

men as Theodore Roosevelt, David Lloyd George, and Aristide Briand, to take but a few recent political illustrations. Most politicians, club and organization workers, and the like, have it well developed; those who lack it usually find that the lack is their greatest handicap in public life.

Everyday experience indicates that social ability is more common, or at least more conspicuous, among women than among men, while mechanical ability is more frequently found in men. Early training and opportunity accentuate these differences, but they probably have a germinal basis, particularly since they have existed for thousands of years and a selective action during this period would intensify them.

More careful analysis (180) reveals that the two sexes are equal in ability to remember names and faces, and to interpret emotions. The male excels in the range of interest and in social information. But the female excels in two of the most significant traits: (1) ability to make judgments in social situations requiring tact for their solution, and (2) accurate observation of human activities that serve as a basis for predicting behavior in others.

Social qualities are associated with temperament (Chapter XX), and have a glandular basis, which points to one of the ways in which heredity plays a part.

The amount of an individual's social intelligence increases somewhat regularly up to the age of about 18; after that it shows no relation to chronological age.

Because of the difficulty in measuring differences in social ability, it is only in the last few years that any effective effort has been made to study it, and even now the several tests that have been used do not measure altogether the same thing. Hence from published results one can infer only general trends, and precise knowledge must be awaited.

The resemblance between brothers and sisters in social intelligence (180) is .44, which is about the same as the resemblance for general intelligence.

One test of social intelligence (133) is made up of two parts. In the first, the candidate is shown 20 photographs; then he is again

shown the same 20, but mixed with 30 others very much like them. The ability to recognize the 20 that were first shown is supposed to indicate the ability of a successful office-seeker, or a well-tipped hat-check boy, to remember a face that has been seen on some previous occasion.

The second part of the examination is a questionnaire which seeks to ascertain the leading facts about the examinee's social life: the number and kind of his intimate friends, ordinary friends, and speaking acquaintances; the range of his social activities; and his attitude toward people as such—whether, for instance, like Jonathan Swift, he loves Man but hates men.

The combination of these two tests, together with others of the same sort which the experimenters tried, was found to be fairly reliable. The "recognition test" (from the photographs) was correlated with the student's ability in rote memory (recalling 30 words) to see whether remembering faces was merely one aspect of general rote memory. There proved to be no connection whatever between the two abilities.

There is found to be no correlation, or virtually none, between social ability as measured by these tests and the type of general intelligence that is measured by the standard mental tests such as were used in the army during the World War. The individual with the lowest "general intelligence" may rank highest in the sort of social intelligence measured by the tests outlined above, as any one who has visited a session of the Board of Aldermen might suspect. There is also no correlation between social intelligence and mechanical intelligence (180).

The gifted children of California again illustrate this point. They excelled their playmates less in social traits than in any others. The order of their superiority was:

1. Intellectual
2. Volitional
3. Emotional
4. Moral
5. Physical
6. Social

They were not, as a group, unsocial or defective in this respect: they were well up to the average or above it. But their superiority was far less in social (and also in mechanical) capacities than in the others listed.

Here, then, is a fairly definite and extremely useful type of mental endowment that is largely independent of the sort of endowment generally described as "intelligence."

This is partly compensation: the dull child, with fewer intellectual interests, turns to social activity as an outlet for his energies. The result may be prejudicial. A group of 25 extremely social boys received a lower rating in 24 out of 26 desirable traits, than did a group of 25 solitary boys who were studied (215). Time may be wasted, bad habits formed. But the boys turned to extreme social activity because they were born that way (216).

Almost all studies of both educational and eugenic possibilities have dealt with what has come to be known as general intelligence. Racial progress is closely bound up with this characteristic, and the eugenicist is justified in stressing it. But the parent, who must take the child as he is and make the most possible of him, should not overlook other types of intelligence, especially since success and happiness in life may be more dependent on them—particularly on social intelligence—than on the ability to manipulate intellectual symbols. Too much attention paid to the intellect, at the expense of the social nature, is certain to be harmful to the average child, whose social and mechanical development should rather be pushed.

A certain level of intellect is necessary for success in business, but above this level, differences in intellect are of negligible importance in determining success, as compared with other differences in personality. Thus in a group of conspicuously successful men, there was found to be no relation at all between the degree of intellect and the degree of success in the business world (21). Neither did the amount of schooling correlate with the amount of success in business—though here again there is of course a level, below which one could not succeed at all.

An immediate application of these facts is in the vocational guid-

ance of the child, to prevent round pegs being shoved into square holes.

Some inherited traits are a complete bar to a given profession. Thus one who has short fingers is not adapted to the piano—he can not span the octave. Neither is the deaf child destined to become a violinist, nor the color-blind a painter, unless of the ultra-modern school. Again, there is a peculiar trait which, because two bones in the forearm have grown together, prevents the affected person from turning the palm of the hand upside down in such a position as to receive a coin (74). An individual who has inherited this trait is obviously not adapted to the career of a porter, waiter, bell-boy, or ward politician.

More broadly, there are hundreds of thousands of boys, and girls too, being pushed, dragged, and browbeaten through Latin and algebra, which are worse than useless to them, when their entire interest and capacity would be better served by taking them out of school and letting them work at something that employs the muscles or emotions, which they possess in abundance, rather than demanding a type of intelligence which they lack.

CHAPTER XVI

DIFFERENT LEVELS OF INTELLECT

That intelligence is a function of the whole child, and not merely of the "mind," much less of some small part of the brain, is seen in an examination of the various levels of intellect. There is a regular connection between "mental" efficiency and "bodily" efficiency. The bright pupils of the California public schools were found (367) to surpass the average physically as well as intellectually—in physical growth and general health as well as in their studies. They average larger even at birth.

The same conclusion emerges from studies of definite, simple abilities, as when 50 particularly bright children in New York City were tested as to their speed of tapping. They averaged 10 years old, but were as tall and heavy as the average child of $11\frac{1}{2}$, and could use their hands in tapping and gripping as well as the average child of $11\frac{1}{2}$. They could use their minds as well as the average 15-year-old. In other words, a group of children selected for their superiority in intellect alone, was also found to be superior in size, in strength, and in speed (173).

An attempt is often made to explain the superiority of bright children by their better care. They are given better nourishment at home, because they come from better homes: put this underprivileged child in the same home, and he will turn out just as well as the others, it is asserted.

Doubtless this does explain a small part of the difference. On the other hand, they come from better homes, in most cases, because they come of better families—families with a higher degree of inherited intelligence. The fact that rich people generally tend to show larger measurements than poor people is not so much because they eat more, as because of this (average) superiority. In some cases it is also a difference in race.

All these facts do not contradict the fundamental fact, which is

axiomatic, that that mind will function best which is part of the most perfect and efficient body—since body and mind are inseparable, as the ancient Greeks recognized better than some moderns.

Going downward in the scale, one finds a regular association at all levels. The lower the IQ, the greater the frequency of bodily defects. There is a constant (though not very close) association between the degree of intellectual brightness and the size of the brain (236); the thickness of the layer of cells just beneath the surface, on which intellectual achievement is supposed largely to depend; the complexity of organization of the brain; the size of the body (sitting and standing height, and weight); the lung capacity and rate of breathing; the coördination of the muscles; the level of metabolism; the temperature of the body; the amount of bodily strength. The last-named is limited by decreased will power at the lower levels of intelligence. A big hulking boy may require six men to hold him, when he has a tooth pulled, but may be unable to register a grip of two pounds on a machine designed to test his muscles. He has the muscles, but they do not respond to voluntary control because of the deficient organization of his nervous system.

The child who is below par mentally not only grows at a retarded rate, but stops growing earlier than do his normal brothers and sisters (83). He sleeps less than the latter (whereas the mentally deficient adult sleeps more than usual).

Not only is there a lowered efficiency of the whole body, accompanying a lowered efficiency of the intellect; but there are innumerable abnormalities of the internal organs, the sense organs (eye and ear especially), the teeth, the circulation of the blood (low mentality being associated with rapid pulse),—all parts of the body, in short (360). There is even a tendency toward perturbed finger-print patterns (278). But it is important to note that, abundant as are the physical peculiarities associated with lower intellectual levels, almost none of these peculiarities is ubiquitous: they differ from child to child, just as the assortment of genes differs from child to child.

These statements apply to children who have developed up to

the level fixed by their inherited constitutions. There are other cases, to be discussed in Chapter XXI, in which an individual's development is retarded by some injury following birth. They offer another picture. But in so far as a child's level of intellect represents more or less fully his native endowment, it is evident that this endowment is a general one, linking together every function of the individual.

Anatomists, physiologists, and psychologists must do a great deal more work before the student of heredity will have the facts at his disposal necessary to explain fully the origin of the various levels of intellect. But the data now available are sufficient to outline the picture. Some of the details are so complex that one does not see how they can ever be filled in.

The association between degrees of gross bodily efficiency and degrees of strictly intellectual efficiency is sufficient evidence, if any were needed, that most or all of the genes in the fertilized egg contribute to the establishment of the final level of intellect. While some must be more influential than others, the number that affect the mind directly is evidently great.

It has been easy for some students to think of these genes as cumulative. Just as a glass of lemonade which contains three spoonfuls of sugar is sweeter than a glass which contains only one, so it was supposed that a mind which received 30 genes for intellect was more intellectual than one which received only 10. Such a picture is too crude to represent the facts.

It must not be forgotten that every individual of the same sex in the world normally contains the same number of genes (there may be special exceptions, but they do not invalidate the rule for the present purpose.) All women are equipped with, and are the product of, an identical set of genes so far as number is concerned; all men are the same, save that the male presumably comprises fewer genes, because of the difference in size of the two sex chromosomes.

Now if every woman in the world is the outgrowth of the same quantity of genes—say 20,000, or whatever the number may be—

then it is clear that the differences between women, so far as they are genetic, depend not on differences in the quantity but on differences in the quality of the genes.

Each of these genes has alternatives; and when Nature deals this colossal deck of cards, no two players get the same hand. The differences in intellect are then not due to the differences in the number of "intellectual genes" received, but to the fact that one child has a certain set, another has some of the alternatives of this set: that one has received the ace, the other only the deuce of spades, not that one has been dealt two aces of spades, the other no cards at all.

All this is obvious enough as soon as it is pointed out, but it has seemed worth while to rehearse it here because it is overlooked in a good deal of current writing.

While intellectual achievement depends partly on the number, it depends much more on the perfection of the nerve cells and the consequent speed with which connections are made between them (375). There is a close association between general intelligence and the speed of conduction of any nerve impulse in a reflex arc (379)—the correlation of .87 is probably about as close to perfect as one could expect to get with the present method of testing.

Although no two of the incredible number of possible combinations of genes will produce exactly the same result, there must be many such combinations that will produce results indistinguishable by present methods of mental testing. However, if for any important gene in this combination some undesirable alternative is substituted, in the shuffling that precedes the union of spermatozoön and ovum, the perfection of the final product—in this case particularly the central nervous system—will be impaired.

Since every one of these genes is interacting with others, the final level of intellect represents the end of a process of development and differentiation extending over many years: rapid at first in the embryo, and gradually slowing down until it stops shortly after puberty in girls, and somewhere about the age of manhood in boys. The ground plan is completed within a few months after the union

of the two germ-cells which form the new individual, and this plan is then followed out with surprising accuracy, considering the intricacy of the process. But it is subject to innumerable slight deviations during its course, so that the final result can not be predicted with exact accuracy—it is safe to say that it never will be.

So far as is now known, the process of development consists essentially of the stimulation, by the genes, of chains of chemical reactions. It is perhaps more than a figure of speech to say that the genes differ not only in kind, but in amount or potency, so that they will not only cause different chains of reactions, but will start them at different speeds; and when a line of development has been started—more definitely, when a series of cell divisions has commenced—at a certain speed, the influence of some other gene may interfere either to increase or decrease this speed, and thereby change the final product. And since no two children have identical sets of genes, no two children can possibly be alike.

The complexity of this process is far too great for the human imagination to grasp, but a very coarse analogy may help to make it plainer. In the construction of an automobile (or any other complicated machine), everything has to be done in the proper order, and if one workman goes ahead too rapidly, or lags behind, the whole mechanism is jeopardized. If the cylinders are set in and closed before the pistons have been inserted, then the latter can not be put in place, and the engine can never work. If a nut is put on a bolt before the washer is set, and the washer is put on afterward, then this washer is not only useless for its regular function, but is dangerous to the efficiency of the machine, since it may drop down into the gears. If a new workman is on the job, who does not know when this washer ought to be put on the bolt, and does not work in harmony with the rest of the construction crew, the machine is almost certain to be impaired in efficiency—although this workman may be a competent man otherwise, highly qualified for his own particular kind of work.

Now if the genes be thought of for the moment as the workmen, and if it be remembered that with each baby a new set of workmen

is put on the job, some of whom have never worked together before, the surprising thing is not that an occasional imperfect product is turned out, but that a perfect or even a workable one ever appears.

The saving feature is that these workmen have been with the firm for hundreds of millions of years, and that, during these aeons, whenever one of them made a serious mistake, he was at once killed and his place given to a son of one of the more dependable artisans; so that by dint of this prolonged and severe process of elimination, all the boys now in the shop are handy men who can take any job that comes along, and collaborate on it in an astonishingly successful way.

The germ-plasm, fortunately, is not like a new make of automobile that has to be put together from the blue-prints: it is a product that has evolved gradually since the first appearance of life on the globe, if not before. During this history, almost every bad combination that is mechanically conceivable has appeared and been eliminated, so that the resulting architecture is incredibly stable. The same old defects, or some of them, continue to appear in every generation, because it is in the nature of the material to produce them; but they continue to be destroyed, so that the germ-plasm is kept stable and may even improve from generation to generation.

If the points are once firmly grasped (1) that intellectual brightness is a product of the whole organization; (2) that it is therefore due to an immense number of genes, every one of which affects in greater or less degree all parts of this organization; and (3) that they all affect each other still further during the course of development, while they are reacting with the environment; no one will expect to predict the intelligence of a child with micrometric accuracy, even if the intelligence of the parents is known.

In a general way, however, it is possible to see what contributions will be made on the average. The child's level of intellect, as measured by present methods, will be compounded of three factors: (1) the direct inheritance of more or less identifiable and specific genes from the ancestors; (2) the modification of this inheritance during early development by internal forces (interacting genes);

and (3) the further modification of the native endowment (which consists of 1 and 2 combined) by external forces such as training and imitation, all of which forces are limited in their effects by the ability of the native endowment to respond to them.

By various procedures, which make up a large part of recent psychology, it is possible to measure roughly these three components. They are not the same with respect to any two measureable traits, because these traits all differ among themselves in the extent to which they are made up of 1, 2, and 3 respectively. On the average, however, it appears that the native endowment (1 and 2 combined) accounts for 80 to 90 percent or sometimes considerably more (193) of the differences of achievement of grown children. This leaves a varying amount, usually from 5 to 15 percent, for the influence of 3. It is a little more difficult to disentangle 1 and 2, but it seems probable that 1 accounts for something more than 50 percent of the individual's make-up.

The differences in these components scarcely need discussion here. No. 1 can be passed on to offspring. No. 2 can not be passed on to offspring, although it is equally inborn with No. 1. No. 3, which can be transmitted from generation to generation in the form of tradition, is of significance only as it affects the combination of Nos. 1 and 2 (Joseph Pulitzer once remarked that "The idiot is the only person who owes everything to birth and nothing to education"), and it affects them in a relatively small degree, in contrast with the large part which Nos. 1 and 2 play in fixing the final limits of achievement of any boy or girl.

The theory of inheritance fits well with the observed facts. In general, brilliant people are most likely to have brilliant children, because they have the largest number of the needful genes, with the fewest inferior alternatives and incompatible genes to pass along. But if an unusually large part of these genes is lost at the reduction division, and something less desirable left as a substitute, then these brilliant people will have ordinary or even dull children.

Owing to the large number of genes involved, it is not to be expected that there would be any observable dominance in intellect,

even if some of the genes themselves showed individual dominance; and a study of an average sample of the population (187) shows that the inferior parent seems to exert just the same influence as the superior parent in determining the score of the offspring. When there is a wide difference between the parents, the offspring tend to be intermediate; but in that case they are no more variable than are those of two parents who resemble each other much more closely in intellect.

Average people, then, will usually have average children, but by a fortunate combination of genes may produce a genius, by an unfortunate combination may produce an imbecile. The subnormal will tend, broadly, to have children about like themselves, but they will have some duller and a few brighter—only a few, because they have relatively fewer desirable genes to give the child, even if the most favorable combination of these genes is made in the spermatozoön or ovum.

The production of an occasional dull child is therefore an unfortunate but inescapable certainty at any level of society; though it will be rarer in the upper than in the lower levels; and it may be taken for granted, novelists to the contrary notwithstanding, that two normal parents will not produce exclusively defective children, as in Joseph Conrad's short story, *The Idiots*.

The kind of child who gets into the special schools or development rooms for retarded pupils is, on the whole, not at all the offspring of imbeciles or of the down-and-outers; he is usually the offspring of parents who are themselves relatively normal. This has been observed in all studies made on the subject, I believe; I found it strikingly confirmed in a study which I myself made of the 2,000 such pupils in the Los Angeles public schools. In most cases, this retarded child seems to represent merely an unfortunate combination of genes; he will be found to be the lowest in intellect of the family, his brothers and sisters representing various degrees of brightness above him. It is a question of levels of intellect.

Many familiar studies have shown that there is a regular association between the economic or social status of an individual and his

IQ (this does not always hold good for individuals, but it is markedly true when any large group is studied), and that this gradation is as strongly marked among children, even at the nursery age (128), as it is among adults, hence it can not be due merely to surroundings and opportunity. Regardless of the explanation, it is for the present purpose merely a fact. But when a group of children at the lower levels of intellect is examined, it is found that they come about equally from all strata. I may illustrate this by two such

TABLE II

Percentage distribution of occupational status of males

	FATHERS OF CALI- FORNIA GIFTED CHILDREN	FATHERS OF 300 GREAT GENIUSES	FATHERS OF MUNICH SUBJECTS	FATHERS OF SONOMA PATIENTS	ALL ADULT MALES IN CALIFORNIA, 1920
	<i>per cent</i>	<i>per cent</i>	<i>per cent</i>	<i>per cent</i>	<i>per cent</i>
Professional class.....	31	52	1	1	4
Semi-professional and busi- ness:					
(a) Higher group.....	31	29	1	2	4
(b) Lower group.....	18	14	20	10	19
Skilled labor.....	12		43	45	47
Semi-skilled to slightly skilled.....	7	4	18	18	18
Common labor.....	1	1	17	24	8
	100	100	100	100	100
Total number in group...	560	300	683	485	1,226,113

widely different groups as the patients released after eugenic sterilization from the Sonoma (Calif.) State Home for the Feeble-minded, and the pupils in the special classes of Munich, Germany, which may be compared (306) profitably, first with the whole male population of California, secondly with the fathers of particularly bright children in the California public schools, thirdly with the parents of 300 of the world's accepted geniuses (Table II).

The class of unskilled labor produces more than its share of the

children at the lower levels of intelligence, the professional class produces less than its share. But in California and Germany alike, the great bulk of these children are not the offspring of the odd-job men; they do not come from the poorhouse; they are the product of the prosperous and efficient group of skilled laborers and artisans; and the reason is clear, namely, that the skilled laborers and artisans make up the largest group in the population. They are merely producing their fair share of these lower levels—no more and no less. The table points strongly to the action of an inexorable assorting of the genes at the reduction division, as I have described.

The jump from the skilled laborer to the professional man is far greater in respect of abstract or verbal intelligence than it is in respect of economic prosperity, in which the former often has the advantage. The mechanic depends more on mechanical and social intelligence (see the preceding chapter) and less on abstract intelligence. The professional classes make their living through the possession of abstract intelligence, and it is precisely this sort of intelligence which the customary mental tests measure and which the testers call "general intelligence." It might be said that the mental tests are made for professional men's children, not for mechanics' children. The justification of this is that they have been worked out largely in connection with the educational system, and they do measure pretty accurately the extent to which a child can profit by the type of formal schooling that is now given.

In addition to the production of low levels of intelligence through this mechanism, there are undoubtedly cases of disordered development due to the interfering action of some specific gene or genes. I shall refer to some of these in the chapter on intellectual deficiency, to others in the chapter on diseases of the mind.

It might make for clearer thinking if the differences in intellectual stature, so to speak, were compared with the differences in physical stature. In each instance, one finds a continuous distribution of all grades from the highest to the lowest, with the intermediate or mediocre grades the commonest; and most of the differences are due to the nature of the assortment of genes received.

But there are other types of difference which may appear at any point on the scale but are perhaps most frequent at the top or bottom. Thus the dwarf does not, apparently, represent a mere product of too few favorable genes, but is the result of the action of a definite gene or group of genes which prevents normal development. He may have all the proper genes, but he has these inhibitors in addition. The effect may be of at least two kinds, in one of which the whole body is reduced in size, in the other of which the trunk is about normal, but the legs greatly shortened.

✧ In the same way there are undoubtedly forms of mental deficiency which run in families and which must be explained by the action of a single definite interfering gene, or several of them, rather than by the regrouping of a large number of alternatives. In practice, it is only in extreme cases that one can decide on one or the other of these explanations with any confidence.

At the other extreme there are giants who owe their unusual growth to unusual genes which stimulate, for instance, the pituitary gland while holding back other ductless glands that would normally balance it and keep it in check. Just how the intellectual giants of the world are to be explained is not an easy question, for the facts to frame an adequate explanation are not yet available. With the present crude methods that must be used in such a delicate investigation, it seems likely that there is really some analogy between excess physical growth and excess mental growth, to this extent, that in each case the growth is due to the absence of the usual mechanism for stopping growth at a certain point. The brakes are out of order and the impulse of development keeps going on. This may produce a development that seems irregular, giving rise to the erroneous notion that genius is akin to insanity.

Whether there is any difference between the average level of intellect of boys and of girls is an interesting and still debatable question. In general, such purely intellectual differences as are shown between boys and girls are of little or no significance. The two sexes differ more widely in everything else than they do in intellect. At the top of the scale, however, there seem to be more

superior boys (367), just as throughout history there have been more superior men, even when full allowance is made for any handicaps of a social or educational nature which women may have had (301).

This difference is explained plausibly by the longer development of the male, whereas the development of the female slows down at puberty and soon stops, due to the heavy demands which the reproductive system begins to make on the organism. It seems likely that this process, through selection, has resulted in giving the female sex a smaller average endowment, since the difference is discernible even before the age of puberty—that is, while there is little or no difference in the average of the two scores, and it may well happen that the brightest individual in school is a girl, yet there will be in the schools of a city more very bright boys than very bright girls.

If one counts the pupils in the classes for the retarded and defective, on the other hand, here again a preponderance of boys is usually found. In most cities of which I have seen reports, from 60 percent to 80 percent of such dull pupils are males. Hence it has been easily argued that the male sex is more variable in every way, and tends to produce more geniuses and idiots alike, while the female sex is nearer the central tendency of the race, the more conservative sex, the less variable.

There is little real stuff in such a facile generalization, and it obscures the facts rather than illuminating them. Boys are more variable than girls in some traits and at some ages; in others less so (138). One can hardly say, without qualification, that one sex is more variable than the other.

The only basis for forming a sound conclusion on this point is to measure all the children in a community. Such inadequate attempts as have been made have led to contradictory results, but the most dependable (25) show that the expected surplus of dull boys actually exists. So far as can now be determined, it seems probable that at every age there are more bright boys than girls and also more dull boys than girls. The former may be explained

by natural selection, the latter perhaps by another appeal to the X-chromosome. The fact that girls are a year or two accelerated, in both mental and physical development, at every age up to adolescence, as compared with boys, gives them a large advantage whenever the two sexes are compared on the basis of chronological age, and has helped to conceal the real facts.

It has often been noted that the dull child is more likely to have a dull mother than a dull father. The situation at the Sonoma State Home is representative. Data were compiled concerning 318 sterilized inmates with mental disease or defect in the ancestry, though not necessarily in the parents. The facts found are set forth in Table III.

TABLE III

Parentage of a group of sterilized feeble-minded persons

	NEITHER PARENT MENTALLY DEFICIENT	FATHER MENTALLY DEFICIENT	MOTHER MENTALLY DEFICIENT	BOTH PARENTS MENTALLY DEFICIENT	TOTAL
Boys.....	51	3	20	8	82
Girls.....	157	1	58	20	236
	208	4	78	28	318

In this case, if one parent is mentally deficient, it is 20 times as likely to be the mother as the father. This merely shows that the dull woman is likely to marry and have children, the dull man not. The latter may be unable to support a wife, and he also lacks both the intellectual and the sexual drive necessary to win and keep a wife. The mentally deficient female easily marries and has children: she is of the "clinging vine" type that appeals to many men, and as she is sheltered in the home and not subjected to the stress of the competitive world, she may get along fairly well where a man with the same IQ, obliged to find and hold a job, would fail.

The remarks in the foregoing paragraph apply to the mentally defective individual in open competition. In isolated communities

the deficient males may marry in large numbers, since they do not have to compete with more normal males for the women of the group. But in any case there is no reason to suppose that the mother plays any more important part than the father in transmitting low intellectual levels, except as stated. The contribution of the two parents is approximately equal (187). There is no evidence of linkage with sex.

The whole problem of levels of intellect has been confused by the human tendency—indeed, it is a human necessity—to classify individuals instead of regarding each one as unique. The unpardonable sin, in this case, has been to lump together as “feeble-minded” all persons who fell somewhat short of what was assumed to be normal. Feeble-mindedness is no more a unit than is feeble-bodiedness. It is really a social term, referring to an individual’s inability to get along well in the community. Biologically it is wholly meaningless unless it is given some arbitrary meaning; and it has so many misleading associations that it might well be abandoned altogether. The average institution for the feeble-minded contains all sorts of people, from the grown man with the intelligence of a month-old baby, up to the boy or girl who tests well above the average, and who is there perhaps because of epilepsy, perhaps largely because of misbehavior and need of a home. They have little in common except the fact of being under one roof, and that is not a biological likeness. The first bearer of the name, Mr. Feeblemind in *The Pilgrim’s Progress*, was no fool but, to use another of John Bunyan’s epithets, merely “chicken-hearted.”

It is customary to go a step farther and divide feeble-mindedness into three strata.

Those who have read the New Testament may recall the story of the foolish virgins who, when they needed to light their lamps at the party, found they had no oil for them. Those who have read their New Testament in the original Greek may recall that these maidens are there designated as morons. The term has come into wide use in the United States as a specific name for the higher grades of mental deficiency. It is used in only one other way in the English

language, I believe—namely in the word sophomore, which is originally sophomoron, “wise fool.” The defective judgment, lack of reasoning power, suggestibility, and absence of foresight and initiative, which characterize many of the morons are well illustrated by their philological ancestors, the foolish virgins of Jesus’ parable.

TABLE IV

Conventional classification of individuals according to levels of intellect

IQ BASIS	CLASS	MENTAL AGE BASIS
		<i>years</i>
0-6	Low idiot	0-1
7-13	Middle idiot	1-2
14-19	High idiot	2-3
20-29	Low imbecile	3-4 $\frac{1}{2}$
30-39	Middle imbecile	4 $\frac{1}{2}$ -6 $\frac{1}{2}$
40-49	High imbecile	6 $\frac{1}{2}$ $\frac{5}{8}$ -8
50-56	Low moron	8-9
57-63	Middle moron	9-10
64-69	High moron	10-11
70-74	Doubtful	11 $\frac{1}{2}$ -12
75-79	Borderline	12-13
80-89	Low normal	13-14
90-109	Average normal	14-17
110-119	Superior normal	
120-139	Very superior	
140-	Exceptional	

Since intellectual deficiency, like intellectual superiority, is relative, it is necessary to define such terms as moron arbitrarily, and this is usually done in terms of the relation which the child’s actual mental attainment bears to the average for his age. In other words, they are classified according to IQ, the most frequently used scale being that published by L. M. Terman (Table IV).

The mental age of the average normal adult has in the past been fixed at 16 years. A child at 16 was supposed to have his full

development of inherited intelligence, and whatever he added after that represented merely experience, not increase in capacity. Tests made of older persons were therefore based on this 16-year level. As an average, this is too high for the United States as a whole, various kinds of evidence indicating that 14 would be nearer the fact. On the other hand, the assumption that intelligence does not increase after 16 is arbitrary: among intelligent people there is usually at least a slight continuation of the growth of intellect for some years more. For these and other reasons, the IQ is only a first approximation to measurement. It is a foot rule, where a micrometer would be desirable. But it is the best now available; it is being improved continually; and it is extraordinarily useful and relatively dependable so far as it goes.

While such a classification as given above is convenient in indicating to teachers how far the child is likely to go in the conventional educational system, as well as in many other ways that have been illustrated in various chapters of this book, it is, as I have said, misleading from the point of view of heredity because it confounds individuals of all sorts of different mental constitutions, and makes the picture seem simple when it is really as complex as the world is populous. The idea that an individual was either feeble-minded or normal led in earlier years to an occasional complete misunderstanding of the facts of heredity, and to the assumption that feeble-mindedness was a unit character, recessive to normality. Although there are undoubtedly instances in which mental defect is due to the action of a single recessive gene, this is far from the usual situation. The normal levels of intellect represent the reaction of the whole individual to his surroundings, and they are dependent on the concurrent action of innumerable different genes, some helping, some hindering, the achievement of a satisfactory result.

CHAPTER XVII

TO HIM THAT HATH—

Victor Hugo was watching Sarah Bernhardt as she brushed the pigments on a canvas (she painted creditably in oils, as well as being a competent sculptor).

"I wish I could paint," he sighed.

"Why don't you?"

"I can't."

"Nonsense," replied the actress. "Anyone who can write or who can act can paint if he tries. I'll show you how."

And she did, so that in a short time he became a passable artist, mainly with pen and ink, however. He and Gustave Doré, with Sarah Bernhardt, used to make sketching tours together in the country during their summer vacations.

Mme. Bernhardt had solved correctly a problem which has been answered wrongly by many who approached it with more learning than she.

Due primarily to differences in heredity, every kind of trait is found in all degrees in boys and girls. Some are good at arithmetic, others can never master long division. Some see well, others have eye troubles from birth; and so on.

Is there a general tendency for children who surpass in one respect likewise to surpass in others? Is the child superior at arithmetic likely also to be superior in Latin grammar? Is the child who sees better than the average apt to hear better than the average, likewise?

Or is there, as has often been thought, a compensation for defects? Is the blind man gifted with better hearing than normal? the child dull at figures likely to make up for it by brightness in languages? the lazy child endowed with compensating cleverness? the brilliant boy or girl handicapped with bad health and shyness?

A great body of evidence has been accumulated during the last

quarter of a century, which demonstrates that the general law of inheritance is a law of correlation, not of compensation. It bears out the saying of Jesus, that many people have found hard, "To him that hath shall be given, while from him that hath not shall be taken away even that which he hath."

The notions mentioned above can be explained easily. The blind man hears well because he has to make the best possible use of this faculty. The child gifted in languages is likely to be enthusiastic over them, and to be indifferent to figures, since he does not see that they have any bearing on his specialty. The lazy child has to be efficient in some ways, in order to hold his own among competitors—thus efficiency experts, studying shop procedure, sometimes ask who is the laziest workman on the job. They know that he is likely to have found short cuts in his work, in order to be able to keep from getting fired and still not sweat too much. The boy who is handicapped by bad health or shyness is deprived of much social outlet, and thrown back on his own resources; he therefore devotes more time to his studies, and perhaps seeks in them a compensation for the success which he is denied in other fields.

Through the development of the calculus of correlation (Chapter XIV), it has been possible to measure accurately such tendencies as these. The present chapter deals only with the inter-relations of mental traits, leaving further discussion of the relation of mind and body to the chapter following.

The relation between parent and offspring, as measured by standard intelligence tests, is somewhere between .40 and .60.

Measurements of all sorts of mental traits in children have shown that most of them are correlated together about as closely in a given child, as his traits are correlated with those of one of his parents; and sometimes correlated much more closely, depending of course on the similarity of traits and their dependence on the same kind of inborn capacities.

One investigation dealt with various types of sensory discrimination: length of lines, intensities of sound, degrees of brightness, shades of gray, and pressures on the end of the first finger. Careful

measurements showed the abilities to discriminate in these ways to be correlated as follows:

Lines and intensity of sound.....	.90
Brightness and intensity of sound.....	.90
Pressure and intensity of sound.....	.36
Pressure and lines.....	.39
Lines and brightness.....	.92
Pressure and brightness.....	.41

While there are wide variations here, the general trend is plainly marked. The boy who has the keenest eye for length of lines also has a keen eye for brightness of colors, for shades of gray, and for differences in sound. Sharp eyesight is not counterbalanced by poor hearing, but it goes with sharp hearing and, to a less extent, sensitiveness of touch.

The higher mental capacities are likewise capable of more or less accurate measurement by standard tests, and prove to be correlated similarly. A favorite test is the "opposites," in which the child is given a word and told to give the word of opposite meaning, his score being based on the speed and accuracy of his replies to a long series. Skill in this correlates .92 with memory of words, .74 with memory in addition, and so on. The same thing holds true of ability in school subjects. The pupil notably bright in any one will pretty commonly be found better than the average in all his subjects. The correlations in a group of children (358) in the fifth to eighth grades are shown in Table V.

The lack of full agreement is partly due not so much to lack of ability as to lack of interest in some subjects, differences in the teachers, and particular preferences or aversions; though there are real inherited differences in ability as well. While no two children are endowed with the same capacities, it will be found in any group that the good things of life tend to go together and that misfortunes do not come singly—to quote the ancient proverbial descriptions of this situation.

Most of the apparent exceptions fall into one of three groups:

1. When one of the traits under consideration is a negative or bad one, high positive correlation would not be expected. Thus the girl

superior in intellect will not also be, on the whole, superior in conceit, or fickleness, or jealousy, but quite the reverse.

2. When the mental make-up represents an uneven breakdown from a former level. In any hospital for mental diseases there will be found individuals of this type—a man, for instance, who has not ordinary gumption to look after the simplest business matter, yet is a good draftsman. His skill with the pen has survived after the deterioration of his reasoning abilities is well advanced. Some such

TABLE V

Correlations between pupils' performances in different subjects

Arithmetic and language.....	.85
Arithmetic and geography.....	.83
Arithmetic and history.....	.73
Arithmetic and reading.....	.67
Arithmetic and spelling.....	.55
Language and geography.....	.85
Language and history.....	.77
Language and reading.....	.83
Language and spelling.....	.71
Geography and history.....	.81
Geography and reading.....	.80
Geography and spelling.....	.52
History and reading.....	.67
History and spelling.....	.37
Reading and spelling.....	.58

persons get into institutions for mental defectives, and then may give rise to the supposition that mental superiority in one line may go with mental inferiority in others—a conclusion that is rarely sound.

X. Y. is a 23-year-old boy at Letchworth Village, a New York state institution for mental defectives. He has a mental age of about seven years—that is, he is near the upper level of imbecility. Nevertheless, he is a pianist of marked ability.

His history (240) reveals a Hungarian family, the paternal line

normal, if not of superior mentality. The father's mother is a pianist of exceptional ability; the father's niece is also gifted; other members of the family, including the father himself, show a moderate degree of musical ability. The mother and her family are persons of superior intelligence, with some emotional instability, but not at all musical. The patient's sister is a clever girl, a violinist but not a remarkably gifted one.

X. Y. was a bright, healthy child, developing normally; as soon as he talked (at 12 months) he began to learn little songs in English, French, German, and Hungarian. He appeared to have musical ability, as well as intelligence, far above the average. He was subject to periodic outbursts of temper, however, which betrayed his unstable emotional inheritance.

Pneumonia and meningitis at the age of three put a strain on this endowment which it could not withstand, and he began to deteriorate. At the age of 23 he has deteriorated in almost every way except in memory and in his musical ability, which remains good with two peculiarities: (1) he can produce no original composition, and (2) he has never been able to learn to dance.

Such a history points plainly to the fact that various mental traits are inherited and develop more or less independently (a fact which does not at all conflict with the general fact of correlation). Moreover, musical ability (Chapter XXIII) is not closely related to general intelligence—although a really great musician must be a person of more than average intelligence. But the feelings for rhythm, pitch discrimination, and the like, which make a competent performer, may be quite independent of the level of intelligence (indeed, they are found highly developed in many Negroes of slight intellect—Blind Tom, for instance). It is perhaps merely a matter of chance that the disease which robbed X. Y. of his general mental heritage should have hit so unequally, leaving most of the musical component, and general memory, almost intact while depriving him of such a commonplace endowment as the ability to point out the absurdity in the statement, "In an automobile accident yesterday one of the drivers was instantly killed. It is hoped that he will soon recover."

3. The third type of apparent exception is that in which superiority in one trait simply represents concentration on that trait; inferiority in another trait simply represents dislike of that trait, unwillingness to exert oneself in it, antipathy to the teacher of that subject, and the like.

The compensation that exists is a matter of function rather than of structure. It is a question of emotional reaction rather than of differences in individual native endowment. Demosthenes, so determined to overcome his speech defect that he did not stop until he was a great orator, represents a type of mental mechanism that often produces striking results, but it can scarcely be cited as vitiating the law of correlation of mental traits. Similar "overcompensation for an inferiority complex" has been used to explain part of the personality of small men like Napoleon who, feeling their physical deficiency, stop at nothing to prove that they can offset it by superiority in achievement. In other cases there may be some organic defect that spurs its possessor on, as in the current analysis of Wilhelm II with his withered arm and peculiar brain. This type of explanation has been pushed rather farther than is justified by some writers; it undoubtedly possesses great importance; but it again has no direct bearing on the subject of this chapter.

To return to the subject of the chapter, why is it that good qualities are thus linked together; that Albert Einstein was able to appear as first violinist with a famous symphony orchestra; that the 10 greatest generals, or poets, or statesmen in history would also be found to be better cooks and sculptors and swimmers than the ordinary man? A number of possible explanations have been suggested.

1. Those who believe mental achievement to be dependent solely on training and the formation of habits would naturally argue that the child from the good home gets the advantage in every way. This is far from adequate as an explanation, as I trust that this entire book will show.

2. One school of psychologists, mainly British, holds that there is a general intelligence factor, which is inherited in different degrees,

and to a certain extent governs, or at least is associated with, all mental qualities. Thus a youth who surpasses in everything has inherited a high degree of this general intelligence factor, which operates through all his other capacities.

This central factor is defined in various ways: sometimes it is thought of rather mystically as the total fund of mental energy. Achievement in any particular trait then depends on this fund of mental energy plus a particular capacity furnished by an inherited factor that deals with the trait in question.

This view does not accord well with the facts of heredity—it is so simple as to be naïve. Whether it meets the needs of psychology is a technical question, the answer to which must be left to psychologists. Most such students do not accept the central factor, with all other traits arranged around it in a hierarchy like functionaries under a czar. They hold that there is a high degree of specialization in mental capacities,—that they are split up, indeed, into innumerable small and distinct units, which are capable of separate inheritance. Such a view accords much better with the facts of heredity, but it affords no explanation of the correlation of good traits.

3. Good traits might be grouped in the same chromosome or set of chromosomes; bad traits likewise. The child would then get a whole good set, or a whole bad set, depending on chance.

It is a fact that genes located in the same chromosome tend to travel along together, so that they reappear in the offspring in association (this is known as linkage), instead of assorting at random as Gregor Mendel supposed. This fact can be demonstrated easily in animals which have but a few chromosomes. It must be true of man, but has not yet been shown, because of the large number of chromosomes. There being 24 of these received from each parent, it follows that the chance, among offspring of two parents, of a given trait—say eye color—being linked with any other given trait—say the shape of the lobe of the ear—is only $1/24$. Hence it would be difficult, given the complexity of human inheritance and the small numbers of offspring observable, to demonstrate any case of linkage.

Linkage, I may say in passing, is itself not final, since a gene sometimes crosses from one chromosome to another. This appears to occur when the chromosomes are stretched out side by side and in contact with each other at various points. A section of one may then change places with a section of another, thus moving a block of genes from one chromosome to the other, just as a railway switchman might exchange various cars in two trains and still have left two complete trains of the same size as before. There is abundant evidence of this "crossing over" in plants and lower animals, but for the reasons give above it has not been demonstrated in man.¹

In any event, all that is known of heredity shows that in general the genes of all sorts of traits are found in the same chromosome, and it is repugnant to reason to suppose that favorable traits would to any large extent tend to become concentrated in one chromosome and unfavorable ones in another, with the minor exception of the unfavorable traits in the male sex chromosome.

4. The reasonable explanation is that good traits are found together because they have common components—they are the result, to a large extent, of the same mental elements. While this is perhaps essentially the same explanation as No. 2, it is stated in a form that fits the facts of heredity better.

5. This is reinforced by the bringing together of good traits in certain lines of inheritance, through the selective mating of men and women in the past. They are kept together by the same process.

On the whole, like tends to mate with like. The tendency is definitely measurable (correlation about .25) for physical traits, and marked (correlation from .40 to .75) for intellectual traits. With temperamental traits, on the other hand, there is a negative correlation—the quiet girl tends to select the animated man, and vice versa. The idea that "unlikes attract," that the tall man will seek the short woman, is based merely on a few conspicuous cases.

¹ Since this was written, evidence has been brought forward suggesting that the inheritance of the blood groups in man (see Chapter IX) is due to two independent pairs of genes, with crossing over between them (14).

Already recognized as incorrect by such a close observer as Leonardo da Vinci, it has been shown to be the reverse of the truth (except in a few matters such as temperament) by exact measurements. People usually marry in their own set and in their own race as well as somewhat on their own mental level. Thus there is a continual bringing together or keeping together of the genes responsible for high degrees of superiority in various lines; just as there is, at the other end of the scale, a tendency for the dull, the vicious, or the handicapped to mate among their own kind.

As long as this process continues, the concentration of similar degrees of superiority or inferiority will continue, and thus will maintain the kind of correlations with which this chapter is concerned.

Given the undisputed facts of heredity, and the undisputed facts of assortative mating, the correlation of traits is not only explained simply and fully, but it is made inevitable. If nothing were known of such correlation, one would be forced to expect it and look for it. Any other result would be incompatible with the known mechanism of inheritance.

Since many of the correlations are low, it follows that many individuals will be found, in whom good traits are not closely associated. As already pointed out, a boy may be inferior intellectually, superior mechanically; nevertheless, the boys who are farthest above the average, intellectually, though they may excel much less in mechanical ability, will by no means be the worst in school in this respect—they will simply be much less superior in the latter than in the former exercises.

This fact is important in the education of the individual child, but its greatest significance is perhaps eugenic: it shows that the perpetuation of strains that are particularly good in any one respect will, on the whole, produce children who are above the average in many other respects. Thus there is no fear that perpetuation of good strains will produce a one-sided, ill-balanced race in the future. The result will be just the contrary.

CHAPTER XVIII

BODY AND MIND

Two veteran editors of the Scripps-Howard chain of newspapers were visiting Knoxville, Tenn., in 1921.

"What a lot of blue-eyed people one sees on the streets of this town!" exclaimed one.

"Blue-eyed people are the kind who appreciate the policies of our papers," mused the other.

"This would be a good place for us to start another newspaper," they agreed.

The *News* was established, and within a year lived up to the anthropological predictions of its founders by becoming the most popular journal in the city.

The idea thus acted upon, that there is some sort of a relationship between traits of body and traits of mind, is often based on racial differences, as it very likely was in this instance. If it be true that blue-eyed people particularly approve of the Scripps-Howard publications, it may be because Nordics approve of these publications. But the idea is pushed much farther than this by popular belief.

The close relationship between body and mind has been insisted on throughout this book, particularly in Chapter XVI. There are two practical questions that arise constantly, and deserve further consideration:

From the form of the body, can one draw any safe inferences about the nature of the mind?

Do changes in the body produce changes in the mind?

1. It is a popular superstition that outward form gives an index to the individual's mental capacities and aptitudes. A number of "systems" of vocational selection and guidance have made money for their promoters, diagnosing talent by the shape of the fingers, the contour of the jaw, and other traits of the sort. Not one of



A

A



B

B



C

C



D

D

FIG. 21. BRAINS AND FACES

The 12 boys who are shown in this and the two illustrations following were selected from a group of 100 boys, without being seen, the only object being to get boys of the same ages (11 or 12 years) and covering a wide range of IQ's, ranging from the idiot (IQ 8) up to an exceptionally brilliant boy (IQ 171). The boys' photographs were then arranged in chance order, to see whether intelligent observers could rearrange them in the order of their intelligence. Illustration from Peter C. Gaskill, Norman Fenton, and James P. Porter, Ohio University.

these has any scientific basis, and all the tests that have been made have shown their claims to be entirely unsupported (197).

The earlier phrenologists made use of the bumps of the skull. Ulysses S. Grant had a particularly large bump of musicality—and he said that he knew two tunes: one was Yankee Doodle and the other was not Yankee Doodle! The later phrenologists are more detailed. “Conscientiousness,” for instance, is for them denoted by a broad, bony chin; “benevolence” by a full, rolling, moist under lip; “love of home” by fullness of the soft part of the chin just below the lip; “judgment” by a broad, large nose; musical talent by an ear of rounding form and “fine quality,” with a deep bell and perfectly formed rim (according to other authorities, a short face with eyes wide apart is the sure sign of musical and histrionic ability!)

Others have exalted the merits of the complexion as an indicator of mental traits. Some youths have asserted that all blondes are fickle and all brunettes inconstant. It is not a given type of complexion, however, but sudden change from one type to the other, that is properly to be considered as an evidence of instability. A dispassionate study (262) by married men revealed no difference at all in traits associated with the two types. In a mixed population made up of a light and a dark race, there would of course be racial differences that might easily cause confusion; and these racial differences are responsible for many hasty and ill-founded opinions concerning the association of mental traits and bodily types.

Not even general intelligence can be inferred from anatomical features or general appearance. As proof of this, two investigators (50) gave uniform photographs of 10 college students to 376 individuals, who attempted to “size up” the relative intelligence of the subjects—whose IQ was known accurately from tests. The conclusions of this experiment are that:

1. The individuals attempting to arrange the pictures of 10 persons according to intelligence could have done as well with their eyes closed as with them open.
2. Any success better than this is due to luck, as was shown by having those

who did well on one set of 10 arrange another set, whereupon their apparent better abilities disappeared.

3. Women are no better at judging relative intelligence from photographs than are men.

4. Older persons have no better abilities in this direction than the young.

5. The more intelligent have no better abilities in this direction than persons with less intelligence.

6. There was a very slight tendency for both men and women to overestimate the intelligence of women from their photographs.

7. The ability to estimate intelligence in this way is lessened when the pictures are not uniform.

8. In judging two pictures, as in judging 10, one might as well close the eyes.

9. A group of two, four, or five judges working together do no better than a single judge arranging the pictures by himself.

10. One professional "character reader and vocational expert" did no better than the average of the 376 persons studied in arranging the pictures.

The reader may try this for himself by studying the photographs in Figures 21, 22, and 23. These represent 12 boys, ranging in intellect from the idiot up to the extraordinarily brilliant. Possibly the few lowest can be identified correctly, but the reader will not be able to arrange the entire 12 in anything like the proper order, and he will be particularly likely to miss on the higher ones. Table VI gives their actual rank based on IQ and, for comparison with the reader's own efforts, the rank assigned by 274 judges who took part in the original experiment (123).

The value of handwriting is no greater than that of photographs, for the estimation of intelligence in individual cases (255). It has been claimed that the form of handwriting is hereditary, but this is doubtful—the effects of imitation have not been ruled out thoroughly. Those who are mentally deficient show some general peculiarities (222), but above this level there is plenty of variation.

A large head has often been supposed to be a sign of superior intelligence, particularly by persons with large heads. W. E. Gladstone fancied that he possessed an extraordinary cranium, and clung tenaciously to the belief that it was a sign of mental endowment. In point of fact his skull was not remarkably large as compared with that of Baron Cuvier, or even Lord Byron and innu-

merable other less known men. In an entire city, it is true that the more intelligent will have, on the average, slightly larger heads than the dullards; but the correlation is not great enough to enable anyone to predict anything in an individual case.

While a large head means a large brain, the large brain is simply a small brain magnified. The individual neuron is larger but the relative relationship of the parts and components is much the same. The number of neurons in the human brain is characteristic of the species and fixed within biological limits: it is, in other words, a

TABLE VI
Ranks of boys according to IQ

TRUE RANK	BOY	IQ	AVERAGE RANKING ASSIGNED
1	H	171	3
2	C	140	6
3	A	128	8
4	E	119	2
5	B	111	5
6	G	99	1
7	K	71	4
8	I	63	7
9	D	55	9
10	F	36	11
11	L	26	10
12	J	18	12

matter of heredity; and mere swelling of the size of the individual nerve cell is not so important for intelligence as is the number, the complexity, and the arrangement of these cells—features that are settled, once for all, before birth.

Over the surface of the brain there is spread a thin layer (about the thickness of a silver dollar) of nerve cells, blood vessels, and supporting tissue. This is the gray matter, technically the cerebral cortex, and it contains perhaps 10,000,000 cells which taken altogether make about a cubic inch of matter, weighing about 13

grams. All of these cells, on which the intelligence of the adult depends throughout life, are in existence by the fifth month of the fetus and, so far as is known, not one is added to the number at any time after birth. This means that they must be built for long and hard service. Consider the nerve cells, for instance, in which originate the impulses leading to the respiratory movements. From the moment of the first breath and cry to the last one drawn on the death-bed 50 or 100 years later, these original cells continue to function under all conditions of rest and activity, day and night.

At birth the brain comprises about one-eighth of the infant's body. It increases 200 to 300 percent in size during the first year of life, only 10 percent in the second year. After the third year it does not grow markedly in size, but the cortex is perfected and becomes active.

The process of education, throughout life, continues to bring out the possibilities that were born in the cortex. But it can add nothing to what was there even before the infant learned to talk.

The shape of the head must be interpreted as cautiously as the size. Looking over the course of evolution, one can not fail to recognize that man has become more "high brow." One of the principal differences between ancient man and modern man, as also between the most primitive and the most advanced races of the present day, is that in the latter of each pair the skull is higher. In this way room has been found for an increase in the size of the brain without necessitating a corresponding increase in woman's pelvis to permit the birth of a larger head—there is also a steady increase in the size of the pelvis, with the course of evolution, but it is not as great in proportion as the increase in the capacity of the skull. While there is thus, in a broad historical way, a correlation between intelligence and the altitude of the forehead, this is so slight within a given race at the present day that it can not serve as a basis for prediction (267). Many a brilliant man is literally a lowbrow, while any institution can show idiots with lofty domes that would reflect dignity on a supreme court.

The human male is almost universally longer-headed than is his



FIG. 22. JUDGING INTELLIGENCE FROM PHOTOGRAPHS

Attempts made by 274 students of psychology showed that it was impossible for them to arrange the pictures of the boys in this and the preceding and following illustrations, in anything like the proper order. The few of lowest intelligence may be picked out, particularly by those who have had some experience with mental defectives; but the bright boy does not seem to show his intelligence in a photograph. Illustration from Peter C. Gaskill, Norman Fenton, and James P. Porter, Ohio University.

female, and the same is true of gorillas,—probably the result of a glandular sex difference. The amount of this difference varies from race to race, however, the discrepancy being more pronounced in some than in others. Children are slightly longer-headed than adults, partly because the occiput, elongated by the pressure in the birth canal, is later flattened by years of lying on the back of the head.

Large features go with large bodies, on the whole; and the “upper classes” have, on the whole, larger bodies than do peasants and the tenement-house dwellers of the cities. This, as I have pointed out previously, is not merely because they get better care (247); it is rather due to a selection that has been going on ever since civilization began, which has given an advantage to those who were most efficient, in body as well as in mind; while the inefficient in these respects have tended to congregate together, to intermarry, and to perpetuate their own characteristics.

The practical (though much over-rated) usefulness of the head-form in anthropology has led to a deal of study of its inheritance, the general conclusion being that it is due to a dozen or more pairs of cumulative genes. It is asserted that numerous positive factors tend to produce a broad head, fewer of them a long one, hence brachycephaly is in general dominant over dolichocephaly (163).

A large aquiline nose has for centuries been considered a sign of power and ability. Napoleon I, who had such a nose, declared that no man with this type of proboscis is a fool. Cyrano de Bergerac would doubtless have concurred in the decision. An examination of great men of history (408) discloses that they do, in fact, have noses larger than the ordinary, but there is probably no mysterious potency about the nose, for superior social traits tend to be associated with any largeness of feature whatever (342). It has generally been assumed that this represents a favorable activity of the glands of internal secretion. Here again it must not be forgotten that these glands are not independent and self-governing; they are merely a part of the whole body, closely dependent upon the central nervous system; and the entire organism owes its start and its limits to the original genes.

The direct connection between the degree of activity of certain internal glands and the intelligence has usually not been found to be large save in certain marked cases of mental deficiency. In a California investigation there was found to be no demonstrable association between intellect and the degree of activity of the thyroid, and this was confirmed in a study of 3500 Cincinnati school children (254) and another of English adolescents (362). The thyroid might well influence obesity; but a study of overweight children (229) showed them to be no brighter and no duller than children of normal weight. They were found to be lively and fond of active games (every connoisseur knows that fat girls are good dancers); and they had superior social standing, which suggests that their inherited tendencies to put on weight were not held in check by the meager diet of a poverty-stricken home.

Juvenile adiposity after the age of six or seven is perhaps more frequently due (95) to under-functioning of the pituitary (Joe the fat boy in the *Pickwick Papers* is a good illustration), and this would also affect the development of the skeleton, hence of the nose. In any event, the case is as with the skull, that it is impossible to make any prediction of intellectuality in individual cases, on the basis of size of nose.

At least four independent genes which influence the size and shape of the nose have been supposed to exist, governing respectively the bridge, the nostrils, the base and the tip. The high, heavy, bowed nose has usually been described as dominant over the broad low nose among whites (90), the reverse among Negroes (78). Shape of nose is little affected by outside influences, except among prize-fighters, though there is a marked climatic association, a short, broad nose accompanying high temperature and high relative humidity (373). The internal nose is equally sculptured by the genes, so that peculiarities of the sinus or other structures may lead to a recurrence of infection generation after generation in a family (20). A recent writer (372) concludes that nose form is governed by a series of multiple allelomorphs, pug being dominant over hooked which in turn is dominant over straight. This



I

I



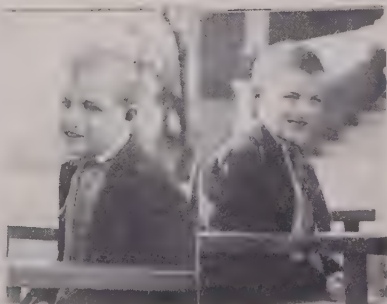
J

J



K

K



L

L

FIG. 23. WHICH ARE THE BRIGHTEST CHILDREN?

Professional "character analysts" have proved to be no more able to distinguish between bright and dull persons, from inspection of photographs, than is the average man. There is a general correlation between good physical characters and good mental characters, but it does not show itself in many definite, recognizable traits of the features. Readers can easily prove this for themselves by trying to arrange in the order of their intelligence the 12 boys in this and the two preceding illustrations. Photographs from Peter C. Gaskill, Norman Fenton, and James P. Porter, Ohio University.

is probably too simple a picture of the facts, but a step in the right direction. Probably the same sort of nose form may arise in a number of different ways; and interfering genes may produce striking abnormalities, the bone of the nose being wholly absent in one family (15).

Most of the supposed evidences of degeneracy—whatever that means—have either been discarded, or the evidence supporting them is so slight that they are not worth mentioning. It is probable that methods of identifying biologically inferior types of constitution, associated with inferior mentality, may some day be worked out. One pointer has been seen in the type of shoulder blade (141-5). The inner margin of this may be either convex, straight, or concave. The two last-named have been classed together as giving the wedge-shaped shoulder blade or scaphoid scapula, and found to be associated with many other peculiarities. Some associations that have been ascribed to the shoulder-blade classification are so striking as to be worthy of thorough investigation. It appears that the wedge-shape predominates in children, while the convex type is found in the majority of old people. Either one changes into the other, a possibility that seems to have been ruled out; or else individuals with the convex type are, on the whole, likely to be of superior constitution so that they live longer. It is further found, in studying large groups of adults, that the wedge-shaped type is found in about half of those who might be called normal—for example, college students and army recruits; while it occurs in three-fourths of those that might be called abnormal such as the insane, the tuberculous, prostitutes, and criminals. Type of shoulder-blade is declared to be inherited as markedly as other anatomical characteristics, concave being dominant over convex. These differences in type are found in the fetus as early as it can be studied; also in lower animals. In exceptional instances they may be changed by a strong influence such as congenital syphilis, during early development.

By and large, there is little relation between anatomic or, as one might say, static characters and mental traits. To find significant

SCAPULAR CLASSIFICATION CONVEX-STRAIGHT-CONCAVE

BASED PRIMARILY ON CHARACTER OF GREATER PORTION OF VERTEBRAL-BORDER CONTOUR BELOW SCAPULAR SPINE.

A



THE **CONVEX** TYPE: MAY BE REGULARLY OR IRREGULARLY, SLIGHTLY: C_v1, MODERATELY: C_v2, OR MARKEDLY: C_v3 CONVEX.

B



THE **STRAIGHT** TYPE: STRAIGHT OR NEARLY SO, NEITHER CONVEX NOR CONCAVE, TENDING RATHER TO CONCAVITY THAN TO CONVEXITY.

C



THE **CONCAVE** TYPE: MAY BE REGULARLY OR IRREGULARLY, SLIGHTLY: C_c1, MODERATELY: C_c2, OR MARKEDLY: C_c3 CONCAVE.

THE **SCAPHOID** TYPE COMBINES 12 OR MORE ANATOMICAL AND ARCHITECTURAL FEATURES COMMON TO STRAIGHT AND CONCAVE WHICH CONTRAST VIVIDLY WITH SIMILAR FEATURES IN THE CONVEX.

GRAVES' AM. J. PHYS. ANTHRO.
VOL. IV. NO. 2 (1921)

FIG. 24. DIFFERENT TYPES OF SHOULDER BLADES

The type of shoulder blade which an individual will possess seems to be established as early as the tenth week of fetal life and thereafter ordinarily to undergo little or no change. In some cases, it is possible that such a disorder as congenital syphilis or rickets may modify it. Groups which are mentally as well as physically inferior in one way or another seem to have more than their share of the straight or concave types which are classed together as scaphoid, while the convex type seems to be in many cases an indicator of biological fitness. This interesting finding deserves further test over a wide range of people. Illustration from W. W. Graves.

correlations, one must usually turn to the physiological or dynamic traits such as were mentioned at the beginning of Chapter XVI. Since the most efficient working of both mind and body is favored by full, normal development, any slowing down or arrest of development, such as produces intellectual deficiency, will be likely to show itself in both body and mind (399).

Because of the tendency of like to mate with like, the genes that promote harmonious and adequate development will tend to be brought together and kept together; while unfavorable genes will likewise be segregated. Thus one would expect to find, as one does find, that a group of children superior in intellect is also above par in muscle, nerve, and emotional control; while the frequency of physical defects found among the inmates of an institution for the mentally defective is likewise striking. But it does not *necessarily* follow that in individual cases a defect in one department will be accompanied by a defect in the other; although there is a general tendency toward this result.

2. Is not intelligence dependent on general good health; and is it not a fact that many children who seem to be dull are merely suffering from illness or physical defect; that with proper medical attention their intellects will also improve?

The general answer to these questions is undoubtedly No.

General health, like general intelligence, is largely inborn; it changes surprisingly little during the whole of the educational period; and the correlation between the two is not high, being as small as .10 in some studies (267).

Philosophically, since body and mind are one, it follows that any alteration in one is an alteration in the other. But the margin of safety in the different parts of the organism is so great that, in daily life, a marked change in one is often not associated with a measureable change in the other. A poisoning of the organism, such as results from loss of sleep (213) or constipation (264) may slow down both physical and intellectual processes, although the lesser poisoning resultant on bad ventilation does not seem to have much effect on mental activity (374). Such a widespread inca-

pacitation as hookworm probably also affects the intellect (350) although here it must be remembered that the more stupid and inefficient families are most likely to acquire hookworm, or to retain it. But in general, and within the range of ordinary daily life, not only is there a surprisingly small association between health and mental characteristics, but there is not even a significant association between health and temper. This again is an inherited trait, not much influenced by digestion or transient bodily ills, though these are often alleged as an excuse for an outburst.

It follows that attempts to improve the child's intellect by surgical operation are largely illusory. Many of the pious stories in circulation, of the miraculous change produced in stupid Johnny after his adenoids were removed, can only be considered fairy tales. There are special cases, as where defective eyesight prevents successful school work, and in which glasses will make a great difference: they will not, of course, change the natural limit of intelligence in any way, but they will give the boy a chance to use what he has.

Yet here again the most careful studies (271) indicate that bad eyesight is not of fundamental importance in producing mental dullness. In particular cases it may be; but on the whole, the association between the two facts is explained by the greater prevalence of defects of eye sight, as of all sorts of other defects, among those who also show mental defect. In other words, bad eyesight is often an effect, not a cause, of general inferiority.

The evidence (223) regarding removal of tonsils and adenoids has been accumulated on such a large scale in recent years that it is conclusive. There is not the slightest reason to believe that these operations, even in extreme cases, will change the level of intellect of the patient (319). If they are needed they should be undergone because they are needed, but no one should expect a child to be brighter afterward than before.

Even the effect on general health is much less than is often claimed. Many of the children actually do poorer work in school for the first year or two, until the effects of the operation have worn off. After that, they return to normal—nothing more.

In certain definite cases there may be special conditions remediable by special treatment. In young children, mental defect due to under-development of the thyroid gland is sometimes helped greatly by administering thyroid extracts. Such examples are not common enough to alter the general tendency of intelligence to be largely independent of bodily conditions that are not inborn.

The association of mind and body goes back to the fertilized egg cell. After development is complete a wide margin of safety has been established; and just as a man's heart may be overworked without producing an abnormal secretion of bile; just as his digestion may be impaired without noticeably altering the activity of his pituitary gland; so his bodily functions may work under a damaging strain without affecting intellectual processes to anything like a corresponding degree.

CHAPTER XIX

CONSTITUTION

It was pointed out in the preceding chapter that there is little or no association between detailed anatomical features of the body and traits of the mind. There is, however (Chapter XVI) some association in a general way between efficiency of mind and efficiency of body; so it is conceivable that there might be an association between the whole bodily type (the physical constitution) and the mental make-up.

Evidence is accumulating rapidly in this, one of the newer branches of the study of man, which indicates that there is in fact such an association.

Differences in the physical constitution are brought about, during the process of development, by the action of the genes, and partly by the influence of these on the glands of internal secretion. Indeed, Arthur Keith has expounded the view that the races of mankind are distinguished from each other principally by endocrine differences.

In the white race, for instance, which is the tallest of the principal races of mankind, the pituitary body and the parts of the reproductive glands that produce internal secretions are represented to be most active, as is also indicated by the body hair. The Negro and the Mongol typically tend to show a beardless face and almost hairless body. In certain Negro types, particularly the tribes of the upper Nile, with their long, stork-like legs, which recall one type of eunuch, there seems to be a marked diminution of the testicular secretion.

The suprarenal capsules seem to perform the function of clearing away pigment from the skin, and in the lighter-colored races they are active, while in the darker their more sluggish secretion fails to destroy the pigmentary bodies that have descended from the

ape. If these glands are injured in a white man, as by Addison's disease, a dark pigment appears speedily in his skin.

The thyroid gland likewise influences the tint of the skin, a yellowish tinge appearing when the gland is defective. It also exercises an influence on the development of the bones of the nose and the base of the skull. When this development is retarded, a Mongolian aspect results. Hence it is easy to conclude that the Mongolian race is characterized by a sluggish thyroid.

Plausible as all this sounds, it is not merely speculative but superficial. If the endocrine glands are responsible for the differences, the genes are responsible for the endocrine glands. They might better be given credit in the first place.

If one admits that there is any such thing as a race, one will admit that the races differ from each other in physical peculiarities, whatever the origin of these differences may be. But within a race, there are also wide differences of physique. The Yankee, who is largely Nordic in racial inheritance, is commonly thought of as long and lean; yet there are all kinds of Yankees, some longer and leaner than others. The Slav is often pictured as short and thick-set; but there are also tall and slender Slavs—at least, some who are taller and slenderer than the average. Thus in any race one can pick out various types, not separated from each other by any sharp line—in fact, there are all grades, which blend together but at the extremes are quite distinct.

While most people are intermediate there are two obvious extremes of type in any group of men—the long and lean contrasted with the short and stout. These two types have been seized on by almost every student of the constitution, and given new names. The most popular just now is to call the narrow, slender, delicate one the *asthenic*; the compact, rotund, heavy and rugged one the *pyknic*. There are all sorts of intermediate and mixed types, representing combinations of these which it is supposed are inharmonious and therefore harmful. There are many other schemes of classification, but the foregoing is as good as any for the purpose of illustration.

It has been supposed that the asthenic type may have arisen on sea coasts, where iodine (necessary to the activity of the thyroid) is abundant, and the short, thickset type, in the interior of continents where iodine is scarce (87). This is a little too easy. Carl Huter made a more attractive (though not less speculative) suggestion half a century ago, that the types represent the preponderance, in development, of one or other of the primitive embryonic layers. If the outside layer (ectoderm) dominates, the thin asthenic type results; if the inner layer (endoderm), the thick pyknic.

Following out this line of thought, it is possible (266) to classify all diseases as to whether they represent primarily the breakdown of organs developed from one layer, or another. It is found that the inner layer, which forms the alimentary canal, is the one that most often fails to live up to requirements. It should follow, then, that the pyknic type, or some modification of it, is biologically the inferior type.

All this is in the best style of the study of the constitution along modern lines—namely, it represents a great deal of pure speculation and a minimum of statistically established fact. Hence most conclusions in this interesting field must at present be received with skepticism.

It should be easy, however, to determine whether a given type of constitution goes more frequently than chance would require with a given disease, for instance.

It has been a matter of every-day observation that persons subject to tuberculosis, or perhaps one might better say to death from tuberculosis, are of the asthenic type—tall (114) and slender, with narrow chest which gives inadequate breathing room. It is not the flat chest that is tubercular, but the round one, which appears to be a survival of the infantile barrel-chest. The flat chest is the healthy chest, having a vital capacity 50 percent greater than the round, narrow type (395).

The asthenic constitution, which accompanies tuberculosis, also accompanies dementia praecox (Chapter XXII), hence it is not surprising to find that tuberculosis is the greatest cause of death

of patients with this malady, 30 to 40 percent of them succumbing to the white plague. The suggestion that the mental disease is really due to poisoning by the tubercle can not be taken seriously; particularly since the opposite suggestion has often been made, that the secretions of the germs of tuberculosis are a valuable stimulant, accounting for the beneficent activity of such men as John Keats and Robert Louis Stevenson. The suggestion that the high death rate is due to the confinement of these mental patients in institutions is likewise not supported by evidence. On the contrary, in a study of 915 families (225), it was found that the mentally normal brothers and sisters of dementia praecox patients also died of tuberculosis much more frequently than normal patients. They also, as is known from other studies, have the asthenic constitution in greater proportion than normal.

On the other hand, manic-depressive patients, who are also shut up in institutions, do not die of tuberculosis more frequently than the rest of the population; nor do their brothers and sisters. The manic-depressive state goes with the pyknic constitution.

The constitution itself then appears to be intimately associated with these diseases, the one mental, the other physical.

Gastric ulcer is also said to be frequent in the asthenic type (87); and if the assertion that cancerous persons are almost always introverts (see Chapter XX) is true (100), the association is more likely to be between cancer and the asthenic constitution than between cancer and the introverted personality, the latter being an accompaniment of the asthenic constitution and doubtless intensified by the disease. The whole question is uncertain, because cancer as a matter of fact seems to attack those who are overweight, people who have 25 percent more avoirdupois than the average of their age having an excess mortality from cancer of 29 percent. Even as slight an overweight as 5 or 10 pounds carries with it a 9 percent increase in liability to death from cancer (234). The exact relation, if any, of this disease to the physical constitution is one of the problems for future solution.

It has also been supposed (418) that there is a special type of

cancer hair, shown by three-fourths of such patients, which is marked by absence of normal glossiness, tendency to dark color, and thickness with infrequency of baldness. This again, if it can be proved, may be a correlative of the general constitution with its glandular differences rather than of the particular disease.

The short, thickset type is associated with gall-bladder disturbance, pernicious anemia, and high blood pressure accompanied by kidney defects (87). It is difficult to separate this picture from that of the fat man who eats too much with his diabetes and liability to paralytic strokes. His gluttony contributes to both body build and disease. After due allowance is made for this, there remain inherited differences of body build as well as inherited differences in the internal factors making for faulty elimination and defective metabolism. Without ascribing too much to heredity, one must not ignore its part in the picture. It has been calculated that not more than 5 percent of the variability in physical traits is due to causes outside the body, (108), and the types of constitution do not seem to be much affected by surroundings (205).

Since the Nordic has some of the characteristics of the asthenic and the Alpine or Slav of the pyknic constitution, it was an easy guess that the two are identical. When one finds a given type of individual succumbing to dementia praecox or tuberculosis, it is not because he is asthenic, but because he is Nordic, it was said.

Such a view may contain a grain of truth, but it is not an adequate explanation, for the diversity of types is found in all races, even those that are considered the purest; it is found equally in lower animals (392). Moreover, it is claimed that the asthenic type which succumbs to dementia praecox is not identical with the type generally accepted as Nordic. While the body build is rather similar, the asthenic is alleged to have a short-round head, in sharp contrast to the long skull which is the pride of the Nordic and the Negro (204, 313). Finally, if the two types were equivalent, one would certainly expect to find mental disease in Scandinavia taking predominantly the form of dementia praecox, in a Slav country predominantly the form of the manic-depressive psychoses. But

the distribution of these diseases seems to be about the same in all races. In admissions to the New York state hospitals (116), the percentage of dementia praecox patients in all the cases of each group was as follows:

	<i>per cent</i>
Slavic.....	46.7
Miscellaneous.....	34.9
African.....	33.3
Hebrew.....	33.0
Italian.....	32.9
German.....	28.1
Irish.....	28.0
Mixed.....	25.4
English.....	15.0

The differences, great and small, all point to the independence of constitution and race. The Slavs, short and thickset, who ought to show no dementia praecox at all, if it is a matter of race, show three times as much as the English, who contain a large element of Nordics.

Approaching the problem from the opposite side, it has been found (155) that the dementia praecox patients in Sweden do not show any higher proportion of typically Nordic characters than does the whole population. Hence it is concluded that this disease is characteristic of a certain body build, the asthenic, much more than of a certain race, the Nordic.

It seems legitimate to infer from such evidence as this that the sort of bodily constitution discussed in this chapter is largely independent of racial type—that it represents an individual and family inheritance that may be found in any race.

That constitution is associated with a given type of disease, should not lead to a fatalistic attitude. One must not suppose it necessary for a tall, slender man to die of tuberculosis. Most of them die of something else. But such a man is likely to be predisposed to tuberculosis, and hence should take particular pains to live biologically.

To sum up this very brief excursion into a large field, one may conclude that:

1. There are inherited differences in body build or physical constitution, associated with differences in disease resistance, or liability to various diseases.

2. These inherited differences in constitution are also associated with liability to certain mental diseases, as I shall describe more fully in Chapter XXII.

3. For this and other reasons mentioned above, it is impossible to avoid the conclusion that differences in constitution go with differences in mental traits.

4. The fundamental unity of the individual is thus again emphasized. Genes that produce a conspicuous effect of one kind are also producing effects in many different parts of the organism.

CHAPTER XX

TEMPERAMENT

During a few minutes of intense mental activity, it is estimated that the number of connections made between different neurons of the nervous system—connections often likened to those of a telephone switchboard—"may well be as great as the total number of atoms in the solar system" (158).

It is easy to imagine, then, that slight inherited differences in the efficiency of this system would make a large difference in the individual's reactions. To this add differences in the make-up and balance of the internal glands, in the blood stream which connects these glands with the nervous system, differences in the tone of the muscles, perhaps even differences in the skeleton (260), and it is easy to see in a general way—even though impossible to understand in detail—that no two children will behave alike under the same conditions.

Evidently the product of these and related factors, acted upon by an infinite variety of outside influences, will be infinitely variable; but it is simple and customary to divide the whole world into a dual classification, for example:

Classic	Romantic
Tender-minded	Tough-minded
Hypokinetic	Hyperkinetic
Sensory	Motor
Conservative	Radical
Thinker	Doer
Strongly-inhibited	Feebly-inhibited
Obstructed will	Explosive will
Mechanically inclined	Socially inclined
Egocentric	Allocentric
Introvert	Extravert

These very general and somewhat vague concepts are not easily defined, much less analyzed into units that can be followed through

generation after generation. If the emotional impulses generated in viscera and glands are strong, and the nervous connections simple so that an idea finds quick outlet in activity, it is easy to see that an individual might be considered "feebly-inhibited." All such descriptions, which are much too simple a representation of the situation (though perhaps not misleading in essentials) offer too many variables to be useful. At present it is possible to deal with the subject only in a broad way, with full recognition of the fact that no two students of it are talking of exactly the same thing.

That the basis of temperament is inherited, and not merely a matter of childhood experiences, is indicated by a number of different lines of investigation.

1. Its early and spontaneous appearance, apart from training. Parents have abundant evidence of the differences in temperament not merely in childhood, not merely in infancy (60), but even while the babe is still in the uterus.

2. Its appearance in lower animals in the same way. Wild rats in captivity, for instance, have an uncontrollably bad disposition and fickle temperament, while the ordinary tame rat is about as temperamental as a child's bean bag. Wild males have been mated with tame females and then removed, so that the offspring never saw their paternal parent. Nevertheless, brought up only with their tame mother, these young have much more wildness than she, and about half as much as the father whom they have never seen (413). Clearly this is inheritance and nothing else. But if temperament is inherited in rats, and in mice (51), why not in boys and girls?

3. Its manifestation in different races with different degrees of intensity that are not explained by any differences in their customs and traditions. The latter must rather be explained as due to differences in temperamental make-up.

4. Several studies (161) have shown that its distribution in parents and children is about what would be expected, if it is inherited, and that different types of matings produce approximately the anticipated results (167).

With rare exceptions, the offspring of two manic parents have been found to be excitable, of two placid parents not excitable, of two depressed parents all depressed; while the offspring of a depressed and a non-depressed parent are not depressed. Normal cheerfulness appears therefore to be dominant and depression recessive (70).

Similarly, a bad temper resulting in violent outbursts seems to be passed along from one generation to the next without any blending or dilution (71), as if it were due to the inherited make-up rather than to the training of infancy. From marriages in which one partner had an explosive temper, the other not, 231 children were produced, of which about one-half (109) had an explosive temper, the others not. Such a result could be explained easily as due to the influence of a single gene, outbursts of temper being looked on as dominant. On the other hand, such an explanation could not be expected to convince anyone who had a different preconceived idea. It is therefore necessary to seek further lines of evidence, such as

5. Correlations of mood and temperament with other characters. They are not markedly associated with changes in the environment, or with changes in an individual's condition, as health, but are to a large degree independent. Among college students, there is no correlation between IQ and temperament (415), and the same situation seems to hold good among patients in mental hospitals (279).

This does not mean that the average individual always shows the same mood: the regular thing is a balance with slight swings to each side, as from grave to gay. When the swings become extreme, they may be associated with mental disease, culminating in the great reversals of mood that characterize circular or manic-depressive psychoses.

The alternation of mood might be related to the idea of incomplete dominance, based on the fact that most people have parents who are unlike in temperament, and therefore inherit both potentialities. Whereas in most traits people tend to marry those like

themselves, in respect of temperament the reverse is the case: there seems to be a marriage selection against similar temperaments and a preference for mating with those who are more or less markedly dissimilar in this respect (70, 71, 206).

Contrary to what the victim himself supposes, these swings of mood do not affect his intellectual efficiency, although they may affect markedly his feeling of achievement. Exact tests (365) have demonstrated that the correlation between performance and cheerfulness is 0, and there is no substantial evidence that some individuals, more than others, are fundamentally impaired by "the blues." The situation here is the same as with feelings of fatigue, unusual temperature and humidity, noise, and the like—the effects actually measureable are insignificant, although the sufferer may think they are tremendous. In the same way neither long imprisonment in the penitentiary nor the immediate effects of typhoid inoculation in the army (414) made any change in the ability to deal with intelligence tests. Not only is temporary emotional upset not closely related to intellectual performance, but fundamental emotional instability shows little if any association with general intelligence among college students (32). Women are found to be more unstable than men, and art students than medical students.

6. Resemblance of mood in identical twins. Innumerable cases are on record, of twins who were so alike in temperament that they suffered from the same mental illnesses at the same time, and had the same symptoms, though in different hospitals, on the same day. There are also other cases in which identical twins have markedly dissimilar temperament; among others, the twins reared apart since infancy, to whom I called attention some years ago (295). Another student, testing these women, reported that they were different in temperament, and drew the conclusion that this is not an inherited trait but due to differences in surroundings (246). Even if the tests used were quite satisfactory—and they are not—the conclusion seems premature. Certainly no two individuals have more nearly identical environments than twins who are joined together physically; yet under these conditions there may be diversities in temperament.



FIG. 25. THE SIAMESE TWINS

These boys, apparently of Chinese ancestry, were brought to the United States a century ago, and attracted so much attention when exhibited that they have become proverbial. They married twin sisters in southwestern Virginia and settled down to the life of prosperous slaveholders and tobacco growers in North Carolina, each raising a family. While ordinarily identical twins exhibit the greatest attachment of affection for each other, and are figuratively inseparable, these boys whose attachment was physical and who were literally inseparable seem never to have been on intimate terms with each other, and after their marriage this estrangement increased until it frequently led to fights. The band which joined them together appeared to be made of a prolongation of the ensiform cartilage which is at the lower end of the breast bone. The above illustration, from a contemporary print, shows them at the age of 18.

A pair of 14-year-old girls of this type has recently been studied carefully (201): "the greatest difference in them was in emotional attitudes." But D. also appeared the more accurate and brighter; she had cut her teeth and menstruated for the first time earlier than V. She is also somewhat taller and more mature than V.

This was true of the "original" Siamese twins, as to whom a contemporary observer noticed that "he who appears the most intelligent is somewhat irritable in temper, while the disposition of the other is extremely mild" (390). It was equally true of a pair of sisters known to history as the Twins of Presburg, who were joined together at the base of the spine. "One was handsome, gentle, sedate, with sensuous character little marked; the other ugly, ill-conditioned, quarrelsome, and of strong passions. Her outbursts of rage against her sister, and their disputes, became so frequent, that in the convent where Cardinal von Saxe-Zeitz had placed them, the inmates were compelled to give them in charge of a watcher, who never left them alone."

Is not the difference in temperament here to be explained in the same way as the difference in intelligence, whatever that may be? The intellectual endowment of identical twins is known by a multitude of tests to be as nearly identical as that of any two individuals can be; i.e., they correlate about as closely as the reliability of the tests will permit. Yet there are exceptional cases like this where there is a difference; and there are more striking cases—one may be normal, the other mentally deficient, due to some disturbance in the course of development. The same may be true of temperament. No one would assume from the two cases just cited that accuracy, brightness, stature, age of maturity, are not governed by heredity. There is no more reason, I believe, to assume, from exceptional instances, that temperament is not equally governed by heredity.

Although no two individuals can have more similar environments throughout life than Siamese twins, the extent to which their environments are really identical offers a nice problem that some ingenious student might attempt to solve with accurate instruments.

The point has been made often, and properly made, that children brought up together in the same family do not have the same environment, in a number of important respects connected with the emotional attitude of parents and offspring.

7. Association of temperament with the physical structure of the body, which is indisputably inherited. Introversion tends to go with a tall, slender type of body; extraversion with a short, thick-set build. The latter combination tends to be socially-minded, whereas both the abstract and the mechanical types of intelligence are more frequently associated with introversion.

Don Quixote represents the introvert type in physique as well as in temperament, just as Sancho Panza portrays the extravert. Or to take illustrations from recent political history, Woodrow Wilson and Calvin Coolidge are as marked introverts as Theodore Roosevelt and Alfred E. Smith are extraverts.

The wild animal is characteristically an extravert. If sick, he appears more introverted, although it is difficult to describe an animal's mental condition because he has no means of explaining it. At any rate, the animal that seems to be markedly introverted is regarded as abnormal. But with the progress of evolution and the development of intellect, introversion increased. The normal, intelligent human being now represents a balance between the two tendencies, but leaning a little more toward the extravert than toward the introvert side. Differences in inborn make-up produce great differences in this balance; it may swing far to one side or the other, and it may also be affected by ill-health, which tends toward introversion (160).

Individuals who show a discrepancy between eyedness and handedness (see Chapter XII) are said to tend toward introversion. Women are normally more introverted than men, and in a group of 1500 educated women, there was found to be an almost universal tendency toward introversion during the menstrual period. The more discomfort and pain, the more introvert was the reaction. Only about one in 200 showed increased extravert tendencies during menstruation—an argument in favor of the glandular connections of this sort of temperament (54).

Moreover, these differences in temperament associated with differences in constitution are just as conspicuous at the school age as in adult life. In one study (202) 79 percent of the children were found to show a concordance of these two traits. Among little children, the jealous boy or girl is also found to be introverted (113). Since the latter trait is inborn, one must recognize that even such an apparently acquired trait as jealousy may have a constitutional basis. Its association with introversion may account in part for the fact (or if not a fact, then a widespread opinion of the male sex) that it is commoner in women than in men.

All this suggests that the personality make-up is much more a matter of development of specific inborn tendencies, than of childhood experiences.

While the general ideas of introversion and extraversion are familiar, a precise definition is not so easy to construct. The behavior of children gives a clue to their make-up. The introvert is neat, perhaps even fussy about personal habits such as eating and dressing; he is sensitive, blushes easily, is deeply affected by either praise or blame, is conscientious to the point of worry, and enjoys a painstaking, detailed job. He does not push himself forward, but speaks when he is spoken to. The emphasis of his make-up being on the processes of thought, he tends to withdraw from reality and to be concerned constantly with himself. Desiring continually to assert himself, he often fails to do so because of some inner inhibition that results in a paralyzing condition of embarrassment. He becomes retiring and timid, and it is only when he is on the way home that he thinks of all the bright things he might have said at the party.

The extravert is the opposite of all this: he is not self-centered, because his interest is more in what is going on around him than it is in his own personality. He is always ready with a laugh and retort, is likely to be a bit aggressive and not easily squelched; he enjoys sports and outdoor life. His tendency is to reach out and make social contacts; he is expansive and expressive; any thought that occurs to him finds ready issuance in conduct.

It is a matter of common observation that such a difference as

this may determine an individual's success or failure in life. Among other things, it exercises an important influence on the choice of a career. The inventor, working alone in his laboratory with his dreams; the poet, sitting in his garret and clothing his fantasies with the semblance of reality; such men can be thought of only as introverts, just as surely as the successful bond salesman, the affluent mortician, and the regularly re-elected district attorney will be thought of as extraverts. Actors, rhetors, preachers, adventurers, bluffers, squanderers, humbugs, are all likely to be extraverts. The latter are found to make the best shop foremen, while introverts are the best inspectors.

Among women, it has been pointed out that those who choose nursing as a career seem definitely to be extraverts; the average of a group tested was found to be more extravert than 94 percent of all women entering colleges, and the most introvert nurse in the group was only as introvert as the average college girl (94). Definite personality traits in which the nurses are more extravert than the college girls are:

Nurses remember better the details of things to be done.

Nurses move more quickly.

Nurses prefer working with others.

Nurses are more ready to share things, even at personal sacrifice.

Nurses are less radical in their views on political and religious questions.

Nurses give less attention to personal appearance.

Nurses are less inclined to day-dream.

Nurses are not as self-conscious.

Nurses are less reserved about making acquaintances.

Nurses are less moody.

Nurses blush less.

If the difference between extraversion and introversion is primarily a difference in balance of the whole organism, due to heredity, it is evident that one would expect inherited differences in such traits as those just mentioned, many of which might at first sight be thought matters particularly of education and associations.

Again, if the choice of a career is determined in many cases by this same balance, it is evident that inheritance must play a large

part in vocational guidance—as in fact it does—and that the tendency of a boy to adopt his father's calling is not wholly a matter of family pull and paternal pride, but partly a matter of the boy's own inherent fitness for and inclination to that calling.

If a boy's tendency to follow in his father's footsteps is primarily due to their similar constitutions, it would be expected that this tendency would run on from generation to generation, reinforced by the strong influence of family sentiment and early training. Thus Hippocrates, according to tradition, was the seventeenth physician in his family; and it probably would not be difficult to surpass the record in modern times, if genealogies were ransacked. Georges Clemenceau, whose medical attainments have been overlaid by activity as a politician, is the seventh doctor in lineal succession in his family. The Porter family of New England has a record to date of eight consecutive generations of physicians (36). An inscription of the time of Darius I commemorates a chief architect in Egypt who had 23 ancestors in the direct line, each of whom had been a distinguished builder.

English boys of the present day tend to take up their fathers' work to just the same extent that they did several centuries ago (273), the author of this particular study concluding that inheritance is responsible for two-thirds of the similarity and family influence or opportunity for one-third. Education, the social structure, and the economic situation have all changed radically during that period; boys have a much wider range of choice before them now than formerly; innumerable trades and professions now exist that were unheard of in the time of the Stuarts; but the strength of inheritance has not altered.

It is too easy to assume that hereditary aptitudes are insignificant in these instances, as compared with family influences. A study of brothers, instead of parent and son, should modify this misapprehension. Pairs of brothers have been studied in both American (198) and English (183) football, and it has been found that in an overwhelming majority of cases they were judged best qualified to play the same positions, although they came into the game years apart and were in most cases rated by different coaches.

CHAPTER XXI

INTELLECTUAL DEFICIENCY

It was shown in Chapter XVI that the appearance of an occasional child of a level of intellect much below (or much above) that of his parents is to be expected, from the shuffling of the genes. In addition, there is unlimited room for the interference of incompatible genes to upset the normal development of the individual. When a child shows intellectual deficiency from birth, it is easy to suppose that one of the above-mentioned causes is responsible.

Many persons, however, find it still easier to suppose that the child is the victim of some sort of accident, and the explanation is often so plausible that it is readily accepted. Even Wamba, whose heredity was no better than that of wicked Max Juke, cherished this delusion. "I was bred to be a friar," he explained, "until a brain fever came upon me and left me with just wit enough to be a fool."

To examine this situation more fully, I went over the histories of some of the sterilized patients of the Sonoma (Calif.) State Home. In case there was any recorded instance of mental abnormality in the family history, aside from the patient, the history was called positive; if there was stated to be no such instance, it was called negative. Records in which information was lacking were set aside as "unknown." This gave among the males 82 positive and 73 negative family histories, among the females 235 positive and 81 negative. In other words, 69 percent of the patients whose history was known at all, had at least one other case of mental disability in their kinship.

In 96 cases, divided among the two groups, relatives offered explanations to account for the patient's mental defect. These explanations are classified in Table VII.

Meningitis, infantile paralysis, and scarlet fever are the diseases most frequently incriminated in childhood. Trauma usually means

a fall; sometimes run over by an automobile, hit by the father with a stove poker, or what not. Birth injury may be due either to application of forceps or less often the result of prolonged and difficult delivery. Under the heading "toxic pregnancy" have been included all the influences that are assumed to operate on the fetus—not merely failure of maternal kidney function but also alcoholism, effects of chemicals taken to produce abortion, and the like; with a case or two in which the child's condition is ascribed to the mother's mental anguish during pregnancy, as was that of the imbecile Barnaby Rudge.

TABLE VII

Explanations given of the origin of certain cases of mental defect

	FAMILY HISTORY	
	Positive	Negative
Diseases of childhood.....	8	20
Trauma.....	12	18
Birth injury.....	11	7
Toxic pregnancy.....	7	9
Miscellaneous.....	2	2
	40	56

As every one knows who has attended to the matter at all, the same sort of explanation, often absurd, is given by relatives in cases where the family history is filled with defect, as in cases where the patient represents an isolated occurrence. Often the explanation is so plausible that it would be accepted at once, if the family history were not known.

Here is a boy who is reported to have been a difficult instrumental delivery; he was not expected to live; he was always a sickly baby. In addition to this, however, he has a very dull brother, an uncle in the Sonoma State Home for the Feeble-minded, his mother is eccentric and very nervous, his great-grandfather and great-grandmother on the father's side both insane. The obste-

trician should not be criticised too severely. The delivery was probably difficult because of the inherited constitutions of mother and child.

Another boy swallowed concentrated lye at the age of 30 months, which accounts to the relatives for his IQ of 46. But his brother, who did not swallow lye, is almost equally lacking in intellect.

In a third instance, the girl's mother attempted to abort the pregnancy, throwing herself on tables and chairs, jumping up and down, beating herself on the abdomen. What more reasonable than to suppose that the fetus was injured? Beyond this, the mother is mentally deficient and has a sister like herself; the alcoholic father has an insane aunt.

Another girl fell from the housetop at the age of two, injuring her skull, and she has never been the same since. Her father, alcoholic and syphilitic, was formerly a patient in one of the state hospitals for mental diseases; her mother is mentally defective and was sterilized by the state 12 years ago; the girl has four brothers and a sister, all of them intellectually deficient; she herself was once a patient in a state hospital for mental diseases, and one is not surprised to learn that she was diagnosed as constitutional psychopathic inferior with criminal tendencies; periods of mutism; pathological liar; homosexual; nomad; kleptomaniac from childhood.

But since the same sorts of explanations are offered in both the positive and negative family histories, must they not be scrutinized as critically in the latter as in the former? H. H. Goddard has argued this point so effectively that it need not be elaborated here. The burden of proof is definitely on those who advance any other explanation than inheritance. An external factor should be suspected on general principles, from a logical point of view, to be erroneous. This does not mean that every case is not to be considered on its individual merits—it means rather that every case *is* to be considered on its real merits, instead of being catalogued as soon as a plausible incident is unearthed in the history.

Syphilis is on the same footing, but it has been studied so thor-

oughly that it is now generally recognized not to be an important factor in the production of mental deficiency. In brief, the amount of congenital syphilis is just about the same among mental defectives as in the normal part of the population; the syphilitic defectives have just about as many defective relatives as do the non-syphilitics; and the level of intelligence of the syphilitic defectives is just about the same as that of the non-syphilitics—perhaps a little higher. Hence there is no reason to suppose that congenital syphilis is an important factor in the production of intellectual deficiency; though it may produce emotional instability or even mental disease.

TABLE VIII
Conditions of delivery

	MENTAL DEFECTIVES		HIGH SCHOOL PUPILS	
	Boys	Girls	Boys	Girls
	<i>per cent</i>	<i>per cent</i>	<i>per cent</i>	<i>per cent</i>
Easy.....	7	6	9	12
Ordinary.....	66	66	36	55
Difficult.....	27	28	55	33
	100	100	100	100

Another of the bogies that has been pushed forward during recent years is the influence of conditions at birth. The Sonoma data permit a closer analysis of this point, since the application blank for admission calls for information as to the nature of the birth, and in 350 of our cases this was given. Table VIII shows the facts, in contrast with those found for 309 of the brightest pupils in the state high schools.

There is no suggestion in these figures that difficult parturition is particularly associated with mental deficiency. If one were going to deal in cause and effect here, one would rather be forced to assume that it is a factor in the production of mental brilliance!

Perhaps the more educated and intelligent mothers of the supe-

rior high school students suffer more at childbirth and therefore describe a larger proportion of their births as difficult, than do the mothers of the defectives. Perhaps they do have more difficult deliveries. It is interesting to remember, in this connection, that the two groups live side by side in the same state, at the same time; in many instances they have doubtless been delivered by the same obstetricians in the same hospitals.

It may be objected properly that ease and pain in a delivery are matters of opinion—they can not be weighed or measured for accurate comparison. The use of forceps is not open to the same objection. Our records for 250 boys and girls at the Sonoma State Home, in which statement was made definitely as to the use or non-use of forceps, show that these were employed in 16 per cent

TABLE IX
Health in infancy

	EXCEL- LENT	GOOD	FAIR	POOR	VERY POOR
	<i>per cent</i>	<i>per cent</i>	<i>per cent</i>	<i>per cent</i>	<i>per cent</i>
Deficient children.....	64		7.0	29	
Brilliant children.....	27.5	46.6	9.3	13.3	3.3

of the deliveries of each sex. Records for 591 particularly bright pupils in the state elementary schools show instrumental delivery of 19 percent of the boys, 12 percent of the girls. Here again there is not the slightest evidence that forceps play an important part in the causation of mental defect. It will be recalled that Dr. Goddard, after a prolonged study of 337 patients, found only one of whom forceps seemed to be the most likely cause of the deficiency.

Our records also describe the health of the patient as a child in 345 cases. These are listed in Table IX, in comparison with the bright children in the public schools.

As we classified our records in only three groups, instead of the five used by Professor Terman, the series are not directly com-

parable. Our grading was "strong," "average or ordinary," and "weak or sickly." More sickly babies might be expected in the group that is producing deficiency, because of the bad family history in a majority of the cases, and the much lower average social and economic level. But it would not require much rearrangement of the data to wipe out the difference. On the other hand, if one puts the worst possible construction on the figures, the differences between the two groups can hardly be made great enough to be very significant, in view of the probable errors that must be attached to them.

The problem was analyzed more precisely by means of correlations. Without going into detail here, I find no relation whatever between the patient's level of intelligence and the ease of delivery, use of forceps, or health in infancy.

This does not mean that in a given case deficiency may not be due to "birth palsy;" or that health in infancy is negligible if it involves such a disease as meningitis, encephalitis (80), or poliomyelitis. But it means that when the subject is studied broadly, among the sterilized defectives of California, these factors are found to be subordinate, to say the least.

If difficult delivery and the application of high forceps leave one child an imbecile and another one mentally gifted, the hypothesis is at least worth investigation that the former child had an inherited constitution which was easily injured, the latter not. If so, the constitution should be considered the primary cause of the defect; and the same line of reasoning applies to disease.

The foregoing study dealt mainly with morons, whose mean IQ was 60, only 35 of them having an IQ below 40. When one goes to the lowest levels, such as are found in an institution, there is somewhat more evidence of the action of outside or at least accidental factors. Some of these factors are well understood.

Thus the cretins are a group in whom the thyroid gland is not working properly. Body and mind alike are stunted, and there are peculiarities such as a lack of sound bone in the bridge of the nose. About one percent of the Swiss population is said to show

signs of cretinism, which may be associated with goiter and often involves deafness—in the Swiss recruiting statistics 80 percent of deafmutism is ascribed to cretinism. The affection frequently attacks several or all the members of a family. Medical opinion generally inclines to look upon it as a sporadic disability that may be congenital but is not inheritable. It would be unwise, however, to assume that the inherited constitution does not play a part in the liability to cretinism. If treatment is begun early and if the case is not too severe, the cretin may be brought up to normal by supplying the deficiencies of his own thyroid with that of sheep.

Mongolism is another well-defined defect, and one which rarely appears twice in the same family. The Mongolian idiot, so called because he has a more or less imaginary resemblance to the Mongolian racial type, is an individual who retains to a large extent the characteristics of the fetus, to which he joins some other peculiarities. The scalp is likely to be corrugated and the tongue marked with furrows, lengthwise, while the sole of the foot retains the oblique line of the fetus that, in normal children, is outgrown in infancy or childhood (38). About half of the Mongolians are idiots, the other half imbeciles, and the sexual function being infantile like the other functions of the body, there is no authentic case on record of a Mongolian marrying and having children. For this reason, nothing is known of the direct heredity (35).

This defect is usually ascribed vaguely to "uterine exhaustion," disordered hormones, or some other similar disturbance occurring in the mother during pregnancy, but such explanations are made difficult by the score or more of non-identical twins on record, one of whom was Mongolian, the other normal. As these twins must have been subjected to the same maternal conditions, they force some other explanation. They would justify the assumption that Mongolism is due to some germ-plasm defect—perhaps a disorganization of the chromosomes. This explanation, on the other hand, runs afoul of the fact that the Mongolian tends to be the last child in a large family, or born of an elderly mother approaching the menopause. A woman over 40 is 23 times as likely to bear

such a child, as is a woman between 20 and 40. This suggests strongly that the mother's condition is in some way at fault, and it is difficult to imagine how this could affect the germ-plasm. The explanation which fits the facts best, though still unproved, is that the defect is due to a faulty implantation of the egg-cell, in such a manner that the membranes surrounding the embryo are too tight. They compress the fetus forward upon itself during the second month of gestation, and the base of the brain does not develop properly. Other characteristics of the child are secondary (381). Changes of the uterus in a woman approaching the menopause would favor such a situation, inheritance would be concerned only in so far as a woman might inherit a certain defect of the womb.

Most of these Mongolians, of whom there are supposed to be from 5,000 to 15,000 in the United States, seem to come from relatively intelligent parents. Since the defect so rarely occurs twice in a family, it is important that a woman who bears a Mongolian first child should not therefore abandon further childbearing. Additional children will be normal, in all probability, and the bearing of such normal children is necessary to remove a cloud that would otherwise be over the mother's mind as long as she lived.

A third group comprises the microcephalics, whose small, peculiarly shaped skulls give them their name. A skull less than 17 inches in circumference is often held to justify inclusion in this class; but it is associated with many other deviations from the average: small stature, drooping shoulders, and a weak nervous system as well as a mind of low development. The defect of the mind seems to be partly due to the small size of the skull.

Males are said to be twice as common in this group as are females. A family often has more than one of these defectives. One family of 10 children has been described, five of whom (four boys and a girl) were microcephalic (17). The father and mother were both of good physical type and mental ability, and there was nothing suspicious in the ancestry, unless it was a history of alcoholism. Families in which the defect appears consecutively in two or more generations are rare.

One married couple has been described, which had microcephalic children; but both members of it, mated to other persons, had normal children. In spite of this, the weight of evidence rather indicates that the defect is due to some error of development, not to the presence of definite genes determining it. In this connection it is significant that women who have been subjected to X-ray treatment during pregnancy are likely to bear microcephalic offspring. Of 44 children born after such treatments, 27 were defective and 14 were classed as microcephalic idiots (248). Apart from furnishing an emphatic warning against X-ray treatments of pregnant women, this points to the method of development of microcephaly, as a disorder of growth of the fetus; but the exact causes, which may be various, must for the present be left undecided.

A fourth group is made up of the "birth palsies," in which the individual is supposed to have been injured by prolonged, particularly difficult parturition, by the unwise application of high forceps, and the like. Reasons were given earlier in this chapter for believing that these causes are of minor importance at the higher levels of intellectual deficiency, but among the idiots there is some reason to think that they play a more important rôle. On a liberal estimate, they can not account for 5 percent of the cases found in a state institution.

The process involved is seen nicely in a pair of identical twins, one quite normal, the other an imbecile (156). The latter had a difficult birth with asphyxia, following which convulsions occurred at intervals for several years. The boys possessed the same heredity, and weighed the same at birth. There were several imbeciles in the mother's family, and the father's side also suggested a weak nervous system by the fact that the grandfather was a drunkard. In short, the boys had an inferior heredity, but in one case it was not put under any strain at birth, and the boy is normal. In the other case, it was put under a sufficient strain to impair it, and the boy is defective. It is not always that the critical line, and its relation to outside forces, is seen so plainly.

A fifth group consists of children who have had some disease affecting the central nervous system. Infantile paralysis (poliomyelitis), sleeping sickness (encephalitis lethargica), and spinal meningitis are the ones most frequently accused, and in a certain proportion of cases, where the disease is either very severe, or the child's organism particularly susceptible (110), or both, permanent defect may be the result.

Apart from these five fairly well defined groups, there are sporadic cases in which the normal development of the central nervous system is interfered with by a variety of internal or external causes. Some of these may be studied in pairs of apparently identical twins that have been reported, one of whom was normal, the other defective. It is not difficult to suggest at least a theoretical explanation of such cases, which will bring them within the framework of heredity as it is now understood. Sometimes an interference with the blood supply of one fetus may prevent its normal development. Or occasionally a mutation may occur in a line of multiplying cells in the body, which will result in a change of direction of development and upset the usual balance. All such occurrences, however, are extremely rare.

All the causes considered in this chapter, put together, probably account for one-fourth, possibly even one-third, of the intellectual deficiency to be found in an institution. The remainder is explained most reasonably along the lines of a preceding chapter, as the result of inheritance. The dullness found in a certain proportion of school children is much more largely a product of inheritance, as I have already remarked, and the outside causes such as I have just been enumerating are even less important here.

Whereas a child whose mental defect is inherited will ordinarily show both physical and mental deviations, a child whose mental defect is due to some later cause may develop almost normally, so far as the body is concerned. It is perhaps more than a coincidence that in a study of school children, retardation or acceleration in anatomical development was found to accompany retardation or acceleration in mental development, in about two-thirds of all

cases (399). This fraction probably represents the number of children whose mental defect was inherited. In those whose retardation was due to causes acting after birth, the development of the body would not be so much influenced.

In constitution, most of the institutional mental defectives are said to be of mixed and disharmonious types (258), though in the female sex the pyknics outnumber these (356). A similar association of temperament, character, and constitution to that existing among normals is found at these lower levels, though with more deviations from the average.

CHAPTER XXII

DISEASES OF THE MIND

While diseases of the mind usually manifest themselves only in adult life, they are foreshadowed in childhood and in exceptional cases the symptoms may be almost as pronounced as in adults. The youngest case of "insanity" on record is nine months! (315).

The earliest symptom of disturbance is likely to be a convulsion, which usually comes on without warning. The infant turns pale, begins to twitch, and loses consciousness. These attacks were formerly looked on as due to indigestion, teething, or what not, and considered unimportant, but studies of the histories of children who have infantile convulsions show that such behavior is often the indication of an unstable nervous system which may give its possessor serious trouble later in life.

In an unselected group of children, one in 14 was found to have had convulsions in childhood. In another series, the history was found in one of 46. Other figures are higher: the true incidence may be as high as one in 10 (370-1). About half of these children proved to be abnormal later in life. The type of nervous system which reacts to poisoning (as in rickets or fever) by a convulsion is one that is injured easily, and the convulsions themselves may increase this injury. Such a child needs careful and continuous protection from overstrain.

The bodily movements associated with chorea or St. Vitus' Dance are less pronounced, consisting usually of sudden, irregular, purposeless, and incoördinate twitchings. They too come in families marked by nervous instability (257), though the direct resemblance is not great. One case is recorded where the disease appeared in seven persons in three generations, but in general only about one patient in 100 gives a history of the same disease in a parent (41).

Under the name of epilepsy there are thrown together a number of different states which have in common the presence of convulsions with loss of consciousness, resulting in changes of personality and, usually, mental deterioration in the end. If the convulsion takes place during sleep it may not be recognized, though the patient often complains of weakness the next morning, and his lips or tongue may show traces of bites during the seizure, or he may find he has wet or soiled himself in the night.

In many cases the convulsion seems to be preceded by a sudden change toward alkalinity of the blood, accompanied by a quick drainage of blood from the brain, which gives some of the lower nervous centers an opportunity to take control of the body. Something of the same mechanism may be noted occasionally by any individual as he is about to fall asleep. The higher centers surrender their control of the body, in the period of half consciousness, and the body often gives a convulsive jerk as the lower centers take over the management for the period of slumber.

A blow on the head, or other injury, also may produce epilepsy in a sound individual; or it may be simulated in hysteria. Hence it is evident that the mechanism involved is a universal one. In the sound individual it will not be troublesome; in the unsound individual it may be; and the unsoundness in question may be reached by many routes.

Only a few individuals who were convulsive in childhood later become epileptic; on the other hand, perhaps half of the epileptics had convulsions in childhood (370-1); and as 85 percent of epileptics manifest their condition by the age of 25, it is evident that this is definitely an affection of childhood and youth. The number of epileptics in the population has been variously guessed as 1 in 500 or even 1 in 200, including twice as many men as women. There may very possibly be in the United States half a million persons with a greater or less degree of this disease, which seems to occur in undue proportion among first- and second-born children. This fact might be explained in the same way as the predominance in males, as due to hard births; hence not primarily hereditary.

When attention is transferred from the symptoms to the constitution, the latter is seen to be distinctive in many cases. The nervous system is out of order, not in any large way but in many small ways. The child is emotionally unstable; he is ready to cry or fly into a rage with slight provocation; his whole behavior is uneven and lacks poise; and as he grows older he may develop an unexpected tendency to lie or steal.

While many epileptics are mentally bright, there is a strong tendency toward retardation, and in some families there is a close association between epilepsy and mental deficiency.

The type of constitution and personality which produces dementia praecox is thought to be rather more liable to produce epilepsy than are some others; and physically an excess of the so-called disharmonious types of body has been noticed among epileptic patients (81, 207) with an almost complete absence of the typical pyknic form (385). Left-handedness and speech defects are more than usually abundant, the cause of this association being uncertain. The general metabolism is somewhat disordered, the glands of internal secretion deranged; and it may be the action of these which promotes irregular growth of the bones, so that the vault of the skull is likely to be unusually thick (120-1). A peculiarity which may be more definitely related to the disease has also been pointed out (377). The pituitary body, one of the most important of the endocrine glands, lies above the roof of the mouth on the under side of the brain in a little depression of the base of the skull which is known as the sella turcica or Turk's saddle because it rises at both ends with a high pommel and cantle, like the saddles of the Arabs and those used by the Mexicans and their successors the western cowboys. The irregular growth of the skull, above noted, may crowd this depression so that the pituitary body has not room to grow and function properly.

In childhood this disability will affect metabolism; later, as the pituitary begins to press on the skull, migraine and many other incidental disturbances are produced. The blood sugar balance may be upset, the consumption of fat in the body impaired, the nerves

poisoned, and all sorts of changes in behavior brought about by such a simple anatomical peculiarity, which therefore offers a plausible, though still theoretical, explanation of some epilepsy. The ancestry of epileptics shows many deviations from the normal, though the direct resemblance of parent and offspring is slight, that is, one rarely finds both parent and child affected in the same way. Thus in one study (42) of 1449 epileptic patients, only 34 parents were known to be affected; but there were 621 cases of serious nervous or mental disease in relatives. In another series, epilepsy was found in 28 percent of the families, though rarely in the parents (29). A third study (148) noted that the disease was twice as common among nephews and nieces of a patient, and four times as common among the brothers and sisters of a patient, as it is in the general population; but even on this basis, the brothers and sisters of an epileptic person are themselves usually not epileptic. In normal people probably not more than one family history in 10 would show any epilepsy.

Altogether apart from the appearance of other cases of epilepsy, the commonest type of family history is one that reveals a weak strain, though the details of this vary with each family, some showing a predominance of mental defect as noted above, others a predominance of other mental diseases, or of alcoholism (a frequent finding, and good evidence of bad nerves); and very generally a high rate of infant mortality. The fact last-named impedes the study of heredity, for many of the children who would have become epileptic had they lived, may have been among the early deaths.

Looking forward instead of backward, one finds similar conditions. Most of the surviving children of epileptics are not themselves epileptic—probably not more than 5 percent or 10 percent will be (324-5, 369).

The frequency of alcoholism in epileptic families has led some people to suppose that alcoholism causes epilepsy in the descendants. Cause and effect are reversed by this supposition, as is shown by a study of the descendants of persons who were suffering from uncomplicated alcoholism. Epileptics (and likewise mental defec-

tives) were rather less common among them than in the population as a whole (324-5).

Any attempt at exactness in the study of inheritance must wait until there are pedigrees available which distinguish the different types of epilepsy. At present not one such is to be had. The general relations suggest that, in the strictly hereditary cases, a number of different genes, mostly recessive, are involved; but occasionally a family is found in which the defect appears to be dominant.

The periodic, neuralgic, sick headaches known as migraine are sometimes said to characterize epileptic stocks, but a study (2) shows that is not correct. Migraine appears to have a distinctly hereditary basis, however. In 92 percent of 400 patients with migraine, either one parent or both had the same trouble. When both parents were migrainous, 83 percent of their children were migrainous; when one parent was migrainous, 57 per cent of the children were similarly affected. Migraine has been said to affect as much as 25 percent of the male and 50 percent of the female population; but not much weight can be attached to figures like this since diagnosis is indefinite and a woman may say that her mother or aunt had migraine, when as a fact the latter merely had a headache resulting from autointoxication or eye-strain (2). For this reason the claim sometimes made that migraine is a simple recessive can not be taken seriously until pedigrees are offered in which the disease has been diagnosed in all the members by acceptable methods.

Epilepsy appearing in childhood is likely to shorten the patient's life markedly, whereas if it does not manifest itself until adult life, it does not cut his career short to a marked degree. On the average, it appears to wear the patient out in about 20 years; so the earlier it starts, the more pronounced will be its effect on longevity. This applies to the more severe cases; many persons recover altogether (120).

Light attacks are not incompatible with first-rate intellectual work, as that of the novelist Gustave Flaubert. The painter

Vincent van Gogh was more seriously affected, until he became quite incapacitated. But most of the alleged instances of epilepsy in great men look like pure fiction, circulated by special pleaders who are determined to make out a relationship between genius and mental disease.

Diseases caused by inherited degeneration of some part of the nervous system are not quite so obscure. The process at work is probably similar in all of these (327), the difference in symptoms depending upon the part of the nervous system that is affected. Among these serious but rare affections, mainly of interest to the specialist, are amaurotic family idiocy, Friedrich's ataxia, and hereditary spastic paraplegia, all seeming to be recessive; and Huntington's chorea, which is a striking and apparently simple dominant.

In contrast to the somewhat indefinite instability of the nervous system, arising in any one of a variety of ways, that seems to underlie epilepsy, a disease like Huntington's chorea is due to a specific gene-difference. Each family studied shows its own slight but characteristic differences from every other, due to the modifiers present (192): thus in one the onset is particularly early; in another there is very little progressive change; in a third there is no mental deterioration; in a fourth the mental deterioration is the most conspicuous feature (73).

This is a parallel to conditions found in the more exact studies possible in lower animals, where the influence of modifying genes has been worked out with great minuteness. A small pattern shaped like a trident, on the thorax of the fruit fly, furnishes a good illustration. According to the definitely-known modifiers present, it may become darker or lighter in intensity, blacker or yellower in color, sharper or more diffuse, larger or smaller, and may change in shape by changes in any of its regions.

Sharply distinguishable from the simple organic diseases just mentioned are the mental diseases which are often called "functional," because they have no (as yet) clearly proved organic cause. The more serious types are often lumped together as "insanity,"

a legal term which means nothing biologically and should be abandoned as merely productive of confusion. A person is insane if he has been declared by a court to be insane. He may be "medically insane" so that the court orders his commitment to an "insane asylum;" he may be "legally insane," which is a more serious situation and indicates that in his actions he either does not know what he is doing or does not know that he is doing what is wrong. But laws and lawyers have tangled up the situation so effectively that, as every newspaper reader knows, it merely leads to interminable litigation. This is made worse by the fact that various states have defined insanity to suit themselves and some, as Colorado, specifically state that idiots and imbeciles come under the definition of insanity. So far as the patient's status as a citizen is concerned, once he has been declared by a court to be insane, he is legally incompetent to make a contract or otherwise exercise the rights of a citizen until he is discharged as "recovered," in which case the court certifies that he is no longer "insane." Meanwhile, the beneficiary of this system may be suffering from the effects of some drug, as alcohol; from the poison produced by small animals in his brain, as syphilis; from being kicked on the head by a mule; from a disordered constitution which he inherited. It makes no difference: he is insane, nothing more and nothing less.

Obviously the study of heredity gets nowhere with such a start. It is necessary rather to go back to the simple idea of an individual, possessing a constitution which is the product of the action of the outside world on his germ-plasm, and able under ordinary conditions to adjust himself to changes around him in such a way as to protect himself and perpetuate the species. If he loses the capacity to make these adjustments, he is sick; the more conspicuous symptoms may be either mental or physical, but both are present because the two are one.

Applying the argument which I used at the beginning of Chapter XIII, it is evident that anyone may become sick, mentally or physically, under a sufficiently great stress. A sound constitution is so organized that it will resist almost any stress short of death; a

weak constitution, badly trained, gives way before some trivial problem, and its possessor seeks refuge from reality in mental disease.

Beyond this, of course, there are insensible gradations from the defective constitution, that breaks down under the stress of even a carefully sheltered life, to the excellent one; and there are exceptional strains which will break down even a constitution that should be regarded as superior. A man who succumbed to "shell shock" after spending four years in the front line trenches in France need not necessarily be condemned for a weak constitution; the strain was so great that any man was perhaps entitled to break under it without being charged with constitutional weakness.

The converse is that many individuals have weak constitutions that would break under an ordinary strain, but because they take particularly good care of themselves, or their families take particularly good care of them, they avoid an actual breakdown, while a brother or sister with similar constitution breaks and so gets into the class of mentally diseased. Since the constitution in the two imaginary cases was similar, but one is classed as diseased, the other not, it is evident that this again complicates the study of heredity.

In general, however, it is perhaps fair to say that the constitution determines the fact of mental disease, in a given situation; the situation itself plus the patient's previous life experience determines the symptoms in detail. The final break represents merely the last weak link in a long chain. Broadly speaking, no one's mind ever gives way suddenly; the symptoms have been present and growing, to the eye of an expert, for years,—really since the moment of conception.

The aggravating factors are not the large affairs of life but the small ones. The agonies of a World War decrease the amount of mental disease and suicide, instead of increasing it (218): war acts as a mental tonic, it draws the individual's attention away from himself; women are less shut in and therefore brood less over real or fancied troubles; only among the soldiers who face difficult situations is there an increase in the rate of mental breakdown. But

the same warrior who has spent years in the trenches may come home unscathed to succumb to a mental disease because he can not solve some small sexual problem of his everyday life.

It is only in a minority of cases that one can even pick out any particular situation that has precipitated the long-developing breakdown (363); then it is likely to be some bodily ill, as influenza, overstrain, or exhaustion, pregnancy or climacteric: or some mental stress, as cruelty or an unhappy love affair.

In short, the mental breakdown is due to the individual's inadequacy to meet an existing situation. The inadequacy is usually due to the constitution,—the fault may in a given case be principally inherent, or principally a matter of wrong habits and defective education. Both elements,—the inherent make-up and the surroundings,—are inescapably present; their exact proportions vary from case to case.

Strictly speaking, then, no two individuals can have the same disease, and no two families can have the same disease. But again the necessity of the human mind, to classify things, causes the symptoms to be stuck into various pigeon-holes where, often enough, they do not fit; the next doctor who sees the patient tries another pigeon-hole, and so on to the end.

Those who break down naturally come from weak stock to a much greater extent than do those who keep going under the conditions of every-day existence. Many studies have shown that at least half, probably two-thirds of the run of insane patients have a history of other cases of mental disease or deficiency in the ancestry (307); whereas in a series of 500 normal families only 3 percent of such histories were found (333); in another series, where the investigators took pains to get really normal persons by including only those who had reached the age of at least 60, and whose parents had also reached the same age (thereby excluding individuals who died young and who might have demonstrated themselves to be mentally abnormal had they lived longer) only 0.39 percent of such abnormality was encountered (378). In 500 superior families in California whose records were compiled with great care and thor-

oughness, only 8 percent were found, of which only 0.7 percent were in the direct line of ancestry (367).

Looking in the other direction, it is found that the offspring of a person adjudged insane will themselves at some time be adjudged insane in a notable proportion of cases, varying in different investigations but rarely less than 10 percent and running as high (157) as 40 percent; while of the offspring of normal parents not one-tenth of the percentage last-named will ever get inside the doors of a psychopathic hospital as patients. It has been calculated (280) that of the total population of the United States, 4 percent will at some time in their lives be judged insane. When the contribution of the weak stocks is deducted from this, the number contributed by the sound parents must necessarily be less than 4 percent.

These general figures show that mental diseases run definitely in families. A closer analysis and the study of separate kinds of disease are necessary to show why and how they run in families.

From 10 to 15 percent of the persons committed as insane in the United States in any one year owe their condition wholly to syphilis. This group seems to be predominantly of pyknic constitution (385). Nevertheless, so far as can now be judged, this amount of insanity is absolutely and completely preventable, simply by avoiding infection with syphilis. Henrik Ibsen's service in making this mental disease known through his *Ghosts* is probably better appreciated by the public than the much greater service of J. von Wagner-Jauregg in showing how it may sometimes be cured by infecting the patient with malaria.

Since not every syphilitic becomes paretic, the disease presumably picks out the weaker strains, as do alcohol and other drugs; injury, exhaustion following fever or childbirth; old age; and the like, which are also avoidable causes, with the exception of the last-named which can be evaded only by premature death.

Not all aged persons break down mentally: many centenarians retain the use of their faculties unclouded. While old age itself predisposes to mental depression in many cases and is normally accompanied by a general deterioration (251), the tendency to act-

ual mental breakdown at advanced age runs markedly in families. Alcoholics were found to break down 10 years earlier than non-alcoholics (230), partly because of the direct effect of the drug, partly because they came from weak stocks as is shown by the very fact of their being drunkards.

Of two brothers, one may break down after influenza, the other will not. The difference may be wholly in the severity of the disease; it is quite likely, however, to be due partly to the inborn differences in the two men. The facts are brought into relief by the case of identical twin sisters (227) who were interned for delusions of persecution during senile involution—one at the age of 69, the other at 73. Since the women had not seen each other for 20 years, it is impossible to suppose that their almost identical symptoms were due to contagion or sympathy. The disease ran a similar course in each, because it was in similar minds.

A young German, coming from a line of professional and academic people, was performing his military service, when he was thrown from horseback. Unconscious for a long time, in the hospital for several months, he never recovered. When well enough to leave the hospital he was taken home by his father, where he steadily demented.

Who, at first sight, would not attribute this to the fall from his horse?

But the young man had an identical twin brother whose history is instructive. The latter had never been sick, and at the time of the accident he was serving in the army in a different part of the country. Yet on the very same day on which Hans became delusional, Fritz also became delusional. Their letters to their parents were of the same tenor—both had ideas of being influenced by other persons, had auditory hallucinations, and thought they were infected with syphilis, although the repeated Wassermanns were negative in each case.

Fritz had a remission, however, and remained in the army until the end of the World War, when he came home and soon developed an organized system of hallucinations identical in content with that

of Hans. In a short time he became as thoroughly demented as the latter (140).

There are perhaps a score of other cases on record (261) in which identical twins have both developed dementia praecox—the disease from which these two young soldiers suffered. There is no case on record in which the disease affected only one of identical twins. It would be difficult to dispute the conclusion that the disease is based on a certain inherited constitution.

It is the most serious of all the great groups of mental diseases. There are under treatment in American institutions at any one time nearly 150,000 patients with this disease, and 15,000 new ones join them annually. They form one-fourth or one-third of all new admissions and, being usually incurable, they accumulate in the hospitals while those with other diagnoses are discharged; so that in most state institutions the praecoxes make up 50 to 75 percent of all the resident patients.

Not only is dementia praecox characteristically a disease of early life, as its name indicates, but it is foreshadowed from childhood, in body and mind alike.

In physique, the patient tends to the asthenic type (154,400), tall and lean rather than short and stout. The latter type is relatively rare, but there are many disharmonious forms which suggest irregularity and disorder of natural growth. The whole machinery is out of gear. The heart is often small and the circulatory system inadequate, whence the general color tends to be pale and cyanosis of the hands and feet is common. The metabolism is low (28); the blood chemistry irregularly abnormal (26-7). The teeth are defective. The whole system of internal glands, including those of reproduction, is somewhat irregular. The invariable discovery of a wide range of bodily disorders, but perhaps no one of them really characteristic or omnipresent, recalls the situation found in mental defect (page 154), and is easily interpreted in the same way—that the individual inherits a certain type of constitution responsible for the disease, but that the details of this are different in each individual and each family, according to the modifying genes that may be present.

The inadequacy of the ductless glands is reflected in the body hair. Whereas the hair on the scalp is usually thick and abundant (204), the beard is frequently deficient in the male and the pubic hair is scant and abnormal in distribution.

The normal difference between the sexes in this respect is that the male pubic hair extends upward in a triangle whose apex is at the navel, whereas the female hair stops in a sharp transverse line, thus forming a triangle with base upward and apex downward at the vulva.

In males with dementia praecox there is a marked tendency toward a female type of distribution of the pubic hair (129). In the female, on the other hand, the pubic hair tends to assume the male form and there is an unusual frequency of hair on the breasts, which is considered to be a typically masculine, not feminine, characteristic (129-32). Thus the growth of the hair, which is a particularly sensitive indicator of the way the glands of internal secretion are functioning, suggests strongly that these glands are out of order.

The patient's behavior indicates it no less plainly. The male is lacking in sexual drive. Due partly to this and partly to diminished will power, he not only tends to remain single, but does not often establish sexual life on a normal adult level of sexuality if he does marry; and the fecundity of the group is low. Sexual activity is commonly directed inward rather than outward, resulting in masturbation rather than fornication. The female, on the other hand, shows an unusual tendency toward abnormal sexual activity in some cases, either illicit with the opposite sex, or homosexual, although masturbation is also frequent. In general terms, it might be said that the male with this disease is undersexed, the female oversexed; and that in each case there is a perversion of the normal sexual drive in the direction of that of the other sex, the male being abnormally passive, the female abnormally active and aggressive. In each case this behavior corresponds roughly with the indications of glandular activity that are read from the body hair.

These bodily conditions form the background for the characteris-

tic behavior of the victim of dementia praecox. From infancy onward, he has a typical schizoid ("cut off") personality—aloof, unsocial, suspicious, introverted, lacking in emotion; a cold, inaccessible nature. These things are normal ingredients of every personality, but in a much less pronounced degree. The real schizoid has them in extreme. It is worth emphasizing that the reactions of the mentally diseased differ only in amount from the normal, not in kind. The conception of normality and disease that was found useful in a consideration of bodily ills (Chapter XIII) is no less serviceable in dealing with mental ills, and the parallel between the two types of diseases is closer than is sometimes admitted.

Prior to adolescence, the patient has probably been a quiet, docile, well-behaved boy, tied to his mother's apron strings but regarded as a lad of promise; rather coddled and not allowed to play much with the neighbors' children because the Williams boy is so rough.

As puberty progresses, he fails to sustain his previous averages in school; finds it increasingly difficult to concentrate his attention on his work, and tends to quit his job or his task unexpectedly. He becomes listless and indifferent to others, careless of his appearance. His emotions atrophy—joy and sorrow mean little, enthusiasm is foreign to him. His temper may become unsteady and explosive; he grows obstinate and unreasonable, perhaps violent if crossed. Control irks him, and he is likely to run away from home. Many chronic vagrants and hoboes are suffering from mild dementia praecox (1): they roam about the country with no particular interest in anything or anybody; while the female of the species is particularly prone to drift into prostitution, due to her lack of normal emotion and her sense of helplessness in facing adjustment to an adult level of mating.

As the youth passes the period of adolescence, and his sexual and other inadequacy becomes clearer and clearer to him, if he does not try to escape his difficulties by actual flight, he becomes more and more panicky and desperate at his inability to meet the require-

ments of normal life. Facing a problem that he can not solve,—a problem that is essentially insoluble,—he finds no escape except in fleeing from the world of reality altogether, and in dwelling in an imaginary world of his own creation. In other words, he develops a psychosis. He retreats within a shell; or like a larva, he spins a cocoon about himself, which the hostile world can not penetrate, and within this he attempts to live in peace. Many of the symptoms of the patient are ingeniously interpreted as regressions to the infantile level, as if the personality were seeking to return to the mother's womb where, protected from every danger, it was omnipotent. The patient becomes a "bench type" on the back ward of some hospital; he will sit all day long in a cramped position like a fetus, doing nothing, feeling nothing, apparently thinking nothing; until death changes the scene.

Not only do most dementia praecox patients show the characteristic schizoid personality from childhood onward (181), but in a majority of cases the same personality trend marked one parent or both; in only 2 percent of one group was neither parent a schizoid (168). This make-up and the body-build associated with it are therefore passed on from parent to offspring; and as the genes that condition this body-build seem to be recessive (see page 96), so do those that condition this personality type. More than one is involved. If one parent has dementia praecox, about 10 percent of the children will also have it. Therefore at least two independent genes are concerned, and it is likely that these are not the same in every case. Certainly what physicians call dementia praecox consists of a number of different types that are somewhat distinct from the biological point of view; in addition to which every patient will be a little different from every other, due to the effect of modifying genes (as well as differences in life-experience which will color the symptoms).

While dementia praecox usually breeds true—that is, if the descendant shows any psychosis at all it will be dementia praecox,—yet there is a frequent appearance of imbecility in the pedigrees. This has been interpreted as meaning that when dementia praecox

has an early and severe onset, the result is likely in many cases to be called mental deficiency. This, however, is only a minor factor in the production of mental deficiency.

On the other hand, mental deficiency is found equally in the ancestors of some dementia praecox patients, and it is likely that the stock in these instances is to be looked upon as mentally deficient from the start. On this stock, dementia praecox is grafted by intermarriage; but there is no real biological relation between the two handicaps (37).

Both dementia praecox patients and those with mental defect show irregularities of finger prints, as compared with the normal, thus indicating that the imperfections of the nervous system go back to the early days of embryonic life, when the finger prints were being formed; but the irregularities in the two types are somewhat distinct from each other (278).

This is one of the few points at which mental disease and mental deficiency seem to overlap, another one being in some cases of epilepsy where deterioration sets in early. In general the two types of abnormality are distinct, one representing a retardation from the outset, the other a development and subsequent breaking down. The two types are frequently found together in a pedigree, but not much oftener than would be expected by chance. An increased frequency may be due to matings which brings them both into a given line of descent.

Direct transmission from parent to offspring is the exception rather than the rule, due to the seeming dependance of dementia praecox on several recessive genes. This also results in an increased frequency of dementia praecox in inbred communities such as that formed by the Parsis of Bombay. In general, the patient is the only one of the immediate family who is so severely affected, but he comes from an ancestry marked by the predisposition on both sides. There is, for instance, twice as much dementia praecox among the cousins of dementia praecox patients as there is in the whole population (394); and grandchildren of a dementia praecox patient have five times as great a probability of manifesting the same disease as has the average person (189).

Part of the predisposition consists of the introverted temperament. Among college students, there was found to be no association between mere introversion and an unstable nervous system. If this is a general situation, then it is clear that there are at least two distinct components of the predisposition to dementia praecox: (1) a group of genes making for extreme introversion (the schizoid personality), and (2) a group of genes interfering with the normal development of the organism, in such a way as to produce dementia. Presumably these two tendencies are inherited separately, and without the dementing factor the introvert is not "insane."

Contrasted with the types of disease grouped under the name of dementia praecox are those of a second large group known as manic depressive or circular psychoses. Here the swings of mood which characterize the normal man or woman—from grave to gay, from excited to sober—are greatly intensified. In between, the patient is likely to be relatively normal, hence the history presents a picture of frequent discharges from the hospital, and a high percentage of apparent but temporary cures, in distinction to the hopeless, progressive deterioration which is usual in dementia praecox.

The body build which predominates among the circular psychoses is that of the short, thickset individual whose ruddy countenance contrasts strikingly with the pallor of the sufferer from dementia praecox. The distribution of pubic hair is much more nearly normal; but patients in whom the normal sex distribution is reversed are likely to suffer from an early onset and more serious course of the malady (131).

Since both the body type and the excitable temperament tend to be dominant in heredity, manic-depressive psychoses behave more nearly as dominant than do those of the dementia praecox group (191).

In the population as a whole it has been calculated (226)—not too accurately, of course,—that the chance of a random individual being affected by any one of the psychoses named is as follows, taking epilepsy as the base line:

Epilepsy.....	100
Manic depressive.....	150
Dementia praecox.....	300
General paralysis.....	600

This takes into account the different frequencies of these four types of mental disease. But if attention is confined to the brothers and sisters of an affected individual, thereby taking account of the intensity, so to speak, of inheritance, the picture is very different:

General paralysis.....	100
Dementia praecox.....	300
Epilepsy.....	450
Manic depressive.....	1,250

In other words, the brother of a manic depressive patient is more than four times as likely to be manic depressive, as the brother of a dementia praecox patient is likely to be also affected with dementia praecox, due to the greater tendency toward dominance of the manic depressive psychoses. These figures, it must be repeated, are not final; they are calculations based on small samples, and suggestive until fuller statistics are available. But all studies agree that the outlook for brothers and sisters of a manic depressive patient, or for his children, is not as good as in the case of dementia praecox (169).

Manic-depressive psychoses in the ancestors are sometimes followed by dementia praecox in the descendants, and there are many cases in which a diagnosis is doubtful: one doctor will call it dementia praecox, the next manic-depressive; or the same hospital staff will change its own collective diagnosis from one to the other a year later. Hence the material offered to the student of heredity is far from ideal, and it is possible to indicate only general tendencies. More specific statements, as that manic depressive psychoses are due to the combined action of two recessive genes and a dominant one, are impossible to prove with the number of authenticated pedigrees available. They may be valid in some instances.

The number of men with manic-depressive psychoses, in institu-

tions, is markedly less than the number of women, the proportion being something like 100:160. This has suggested that a sex-linked dominant gene is involved. On the other hand, the number of men may be reduced by the fact that many of them have committed suicide. This is one of the characteristic outcomes of the depressed phase of a circular psychosis, and as in general many more men than women kill themselves (three or four to one), the number of males with this diagnosis has been reduced artificially, so to speak. Finally, an affected woman may be more likely to be kept at home than is an affected man; hence she does not get into the public records.

The intermarriage of strains with different disease tendencies will produce offspring in whom the rudiments of both dementia praecox and manic-depression exist, giving rise to mixed types that baffle classification.

In spite of all these complications, few will deny that in each group there is a nucleus which is typical, and that the two groups are fundamentally distinct in body and mind. This distinction extends down to details: thus in tests of the senses, the manic-depressive group showed increased sensitivity to color, the dementia praecox group increased sensitivity to form (96).

From what has been said, it will be evident that the number of people in the community who are carrying at least a few of the genes involved in mental diseases is much greater than the number who are ever committed as insane. It is only when the genes reach a certain concentration, so to speak—when the complementary ones are brought together—that their bearer is likely to fail in attempts to meet his daily problems, and therefore to be declared mentally ill.

Does the possession of only a few of these genes affect the personality?

There can be little doubt that the answer must be affirmative. Character peculiarities and nervous disturbances are not only more frequent in the non-insane ancestors of insane patients (185), but also in the non-insane descendants of the same patients (43).

The less serious forms of mental maladjustment, which are often

lumped together under the name of neuroses, certainly represent a combination of "mental" and "physical" symptoms, but it seems likely that the inherited defect is a generalized one, resulting in an impaired nervous system, and that the exact nature of the symptoms is determined, on that foundation, by the individual's own experiences. The frequency of character anomalies, of alcoholism, and of other symptoms of bad nerves (334) in the relatives of persons who have mental breakdowns indicates, as noted in the preceding paragraph, that the lighter troubles represent in many cases merely a single dose of the genes which, if concentrated from both sides of the ancestry, will result in a psychosis. If this is true (material does not exist at present to prove it conclusively) then the conspicuous symptoms which lead patients to be classified in one group or another probably give little clue to the real effects of the genes that lie at the bottom of the difficulty.

The common feature of these neuroses is the inability of the patient to meet the problems of every day life fairly and squarely, and his attempt to evade these difficulties by some means that will protect his self-esteem. Such mental mechanisms are protean. The patient may develop delusions of grandeur—whatever his misfortunes may be, he is really a superman, and if the present generation does not appreciate him, posterity will. He may develop delusions of persecution—if he does not make good on his job, it is not his fault; the boss "has it in for him," or else his independent spirit has caused him to be blacklisted by the Masons, the Knights of Columbus, the Ku Klux Klan, or "Big Business," as the case may be, and this powerful and jealous enemy is secretly thwarting all his efforts. The paranoid with such delusions is arrogant, distrustful, egotistic, and unable to reason correctly when his pet animosity is involved; a sudden irresistible impulse may lead him to kill at any time.

He may develop delusions of illness or disability—if he does not do all that is expected of him, it is because he is really a sick man,—people do not appreciate what a struggle he is making against odds. This is known as hysteria and may take the most striking forms, as in the so-called shell shock cases of the World War, when a man who

unconsciously did not want to face the bullets would suddenly become deaf and dumb, or develop a paralyzed leg, or display some other extraordinary impairment of his faculties. The deceit was wholly unknown to the victim, but none the less real. Many of these serious cases of disability were cured miraculously when the guns ceased firing on armistice day. There is no uniform constitutional group involved here, but the constitutional type colors the reactions: the asthenic victim of hysteria will behave somewhat differently from the pyknic (96). Many shell shock patients were found to come from dementia praecox families. The every-day type of hysteria, or at least its germ, is seen in the dissatisfied housewife who gets special consideration from her family by producing a sick headache when special demands are made on her; the disappointed girl who wins the public attention that she craves by having a fit; the business man who does not feel well on Sunday morning and thinks going to church might make him feel worse, so plays golf instead.

All these mental mechanisms are, in a less accentuated form, quite normal and universal: it is only in the unhealthy individual that they develop into a disease of the mind. The relative contributions of the individual's inheritance and his life history are variable, but careful analysis will nearly always show an unsound nervous system in the ancestry. This may express itself in still other forms such as neurasthenia or weak nerves, a condition in which the individual becomes tired too easily and is oversensitive; or constitutional psychic inferiority, a term which is a sort of waste basket to catch a lot of cases that are not wanted in any pigeonhole. The "CPI" is usually diagnosed by his conduct: the term is a description of abnormal and anti-social behavior, and takes the place to some extent of the older term "moral imbecility."

Still another individual seeks refuge from his troubles in alcohol or opium. Such a course is just as much an evidence of mental disease as is that of the soldier who develops a shell shock before he has ever seen or heard a shell. Experiments (171) show that the individual who has less resistance to the effects of alcohol is different

physically from the individual with high resistance, and that this difference is in the general direction of inferiority. He is shorter in stature, lighter in weight, less given to active exercise, less competent in his work and less able to learn by practice; and his pulse rate is less changed under the influence of alcohol. He is an incompetent machine, and he seeks to compensate for this inferiority (which may of course take many other forms than those mentioned) by drinking. Chronic drunkenness is as much a mental disease as any other condition that sends a man or woman to the hospital, and the history of such cases leaves no doubt that the disease runs in the family.

It is not necessary here to go further into this fascinating field of research, which is the territory of mental hygiene and which has been described abundantly during recent years. The point to be emphasized here (because specialists, concerned about the symptoms, themselves sometimes fail to emphasize it) is that these failures of adjustment are based on some constitutional inferiority. At this weak point the strain of dealing with life's difficulties is greatest and most intolerable. The normal mental functioning becomes distorted under the stress, or as a result of the conflict of several contradictory impulses. The constitutional weakness is in some cases due to outside influences, as for example prolonged illness, more frequently it reflects an impairment of the organism, due to the action of disharmonious genes in development.

Since a delicate mental equipment is most likely to break down, the idea has arisen that genius is closely related to mental disease. This is an incorrect and misleading way of looking at the facts, and is not supported by evidence. The amount of mental disease serious enough to be called insanity, among the world's accepted men of genius, is not more than two (175) to four (93) percent. Since it is at least four percent in the American population as a whole, the man of genius is not more likely to go insane than is the random man in the street. He does have mental and personal peculiarities, due partly to mental specialization, partly to absorption in work that interests him; but these are exaggerated because their

possessor is in the limelight and every action is noted and commented on. Those who argue that genius is accompanied by mental abnormality seem to have taken as their standard of perfection a sort of vegetable morosity that is not more typical of average human nature than of genius.

The fact that one has a delicate and highly-organized nervous system, which is liable to break down if not well cared for, is no more a cause of regret than is the fact that one owns a \$500 chronometer, which is more likely to get out of order than is a ten-cent-store hour-glass. The chronometer permits its possessor to accomplish things that would be mere dreams to the owner of the hour-glass; so does the sensitive, easily injured nervous system. In either case the intelligent man will rejoice that he has a delicate instrument, will learn how to give it the necessary care and then will make the best possible use of it.

CHAPTER XXIII

THE ARTS

That musical talent is at least inborn, is generally recognized both by musicians and by the public in general. It often appears so early, and in such a pronounced degree, that it is quite evidently not the mere product of lessons and practice.

If inborn, is it also inherited? A study of the ancestry of the great musicians shows that most of them came from musical families. This could be interpreted to mean that persons who are themselves passionately devoted to music would use every effort to perfect their children in it, and inheritance would thus be discounted. Karl Maria von Weber's father was so fanatically determined that his son should be a musical prodigy that he gave the child no rest, harassing him until he almost alienated him from the career for which he had such a great predisposition.

While most great musicians have come from a markedly musical ancestry, there have been a few at least apparent exceptions. There is no known music in Christopher Gluck's ancestry, and he seems to have adopted it as a career in spite of all discouragement. George F. Handel's experience was the same. J. S. Bach seems not to have had much encouragement, although his surroundings were almost entirely musical. The familiar anecdote relates that he was refused access to some music which he wanted, so that he was obliged to copy it surreptitiously by moonlight, at the age of 10, during a long series of nights. Richard Wagner's home surroundings and early tastes inclined him toward poetry and drama rather than music; the latter art did not begin to gain the ascendancy until the age of adolescence.

Such facts suggest that parental encouragement is not wholly responsible; still, any one can interpret them in accordance with his own preconceived ideas. It is necessary to find some more critical evidence. One might cite Jules Massenet whose father,

an engineer officer under Napoleon I, was very little inclined to music. By his first marriage he had four children, none of whom was musical. A second marriage to Mlle. de Marancourt, a concert pianist, produced four more children, all of them markedly musical—Jules being one of them.

Still more striking is the history of Franz Anton von Weber, a musician of more than ordinary ability and member of a highly musical family, with which the Mozart family had intermarried. Franz Weber was a bit envious of his kinsman Wolfgang Mozart, who had sired a boy prodigy, the more famous Wolfgang Amadeus Mozart; and he was desperately determined that he would have a child who should uphold the Weber reputation against that of the Mozarts. His wife came from an unmusical family, however, and of their two boys and two girls, not one was more than mediocre in music, though this was certainly not due to any lack of encouragement from their father.

The death of his first wife permitted Franz Weber to marry again, and this time he took pains to choose a partner who was herself highly musical and from a musical stock. Their only child was Karl Maria von Weber who, if he did not quite rival old Mozart's boy, at least furnished his father with ample material for bragging to the neighbors.

Once in a while a puzzling problem of this sort is solved unexpectedly. Thus J. A. Mjølén studied a family of seven children, all of whom were extraordinarily talented musicians (242). In seeking to account for their ability he found that the father and all the father's family, while "musical" were not much above the average. The mother was a well-known and brilliant European concert player, and it seemed natural to ascribe the talents of the seven children to her, until further study revealed that her own ancestry was wholly unmusical. As children ordinarily do not inherit from the individual parent, but from his whole stock, it was hard to understand how seven gifted musicians could have come from the mating of two stocks which had little or no great endowment in this direction.

"For a long time this extraordinary case was a mysterious problem, until one day the enigmatic veil was lifted by a member of the family with the words: 'I do not see why you should not know what so many relatives and friends are acquainted with. *She* (the European concert player, mother of the seven gifted children) *was an illegitimate child*. Her real father was a great musician, belonging to a family of artists!'"

The case at once became plain. In general, it may be said that the more fully the family relationships of any musician are studied, the more certainly will they fall in line with the expectations that would be derived from a knowledge of heredity. Several such studies, covering many thousands of individuals, have been made (149, 200, 383) and they fit in better with the theory of heredity, than with any other theory.

The background of musicality seems to be a sensitive nervous system, which in pronounced cases may lead to the sort of extraordinary conduct that is related of so many great artists; or even to a complete mental breakdown, as was the case with Robert Schumann. But if one tries to get away from even such general notions as this, one must separate out minor and definite traits, each of which can be measured in a laboratory and is not likely to be confused with any other. More than a score of such traits have been isolated and described (339):

I. SENSORY CAPACITIES

A. Pitch

1. The sense of pitch
2. The sense of timbre
3. The sense of consonance

B. Time

4. The sense of rhythm
5. The sense of time

C. Intensity

6. The sense of intensity
7. Acuity through the pitch range

II. MOTOR CAPACITIES

A. Pitch

8. Instrumental control of pitch
9. Singing of (1) key and (2) interval
10. Rating of (1) timbre and (2) range of voice

B. Time

11. Free timed action
12. Regulated action
13. Rhythmic action

C. Intensity

14. Instrumental control of intensity
15. Volume of voice

III. REPRESENTATIVE CAPACITIES

A. Imagery

16. Auditory
17. Motor
18. Visual

B. Memory

19. Auditory memory span
20. Visual-motor association
21. Auditory-motor association
22. Speed and accuracy of learning

C. Imagination

23. Imagination type
24. Creative imagination

IV. GENERAL CAPACITIES

25. Intelligence quotient
26. Emotional type

If tests for these and similar traits could be applied to a large number of related people, through several generations, one would get a pretty good idea of the hereditary relationships. Incidentally, any child who ranked high in most or all of them would be likely, if given the proper encouragement, to become a creditable musician. It is now as stupid for a teacher to give a child music lessons without having made any tests to find out how far the

child can profit by them, as it would be for a railway company to put a man in the engineer's cab without finding whether he was too color-blind to read the signals.

Some tests can be made in a rough way by anyone who can borrow a tuning-fork and metronome. Others of the most valuable are now available as phonograph records.

I will here enlarge on only a single example. The note A', international pitch, is given by a string which makes about 435 d.v. (double vibrations per second). The next note, Bb, requires some 470 d.v. Although there are approximately 35 vibrations in the interval, there have been exceptional persons who could not distinguish one of these notes from the other.

The test of pitch discrimination is made by sounding, say, A, and then a note just a few vibrations above A. The most perfect musical ear can distinguish a change of one-half a vibration, or even less; it would recognize half a hundred different notes in the interval between A and Bb.

One whose ambition is limited to the pianoforte does not need so good an ear as one who aspires to play the horn, while the latter can succeed with an ear that would disqualify him as a violinist. Ability in this direction has been found to be inborn (337), and little influenced by practice (352), but there is still some doubt to what extent it is inherited. It (like many of the other abilities here discussed) depends on peculiarly fine adjustments and sensitive organization of parts of the ear and brain. It is quite possible that these are, to some extent, chance products of development, like the details of the finger-prints (p. 46).

The various musical capacities, so far as studied, have not been found, on the whole, to be associated with each other in any pronounced way,—that is, no more than one expects of good traits in general. All of them tend to increase with age up to maturity (103), and in later life to decrease as the tissues of the body become more flaccid, callous, or hard with advancing years. Moreover, the various capacities are not highly correlated with general intelligence (172).

Probably the exceedingly delicate discrimination that goes with great musical capacity has had no value in natural selection in the past. It did not make its possessor any more likely to survive and to leave offspring. Hence it has not been tied up with other traits closely. Normal hearing was necessary to survival, and is therefore inherited strongly. The ability to distinguish between the most delicate shades of tone is more a luxury than a necessity.

The most valuable studies, for determining heredity, are those in which families have been tested for the separate constituents of musicality. What little work has been done along these lines (241, 357) tends, in a general way, to confirm the results of the studies of family history which have been mentioned earlier. If both parents are superior in a given trait, the offspring are likely to be superior. If both parents are bad, the offspring are likely to be bad. If one parent is good and the other bad, the children are likely to show more variation, good, bad, and indifferent all being represented.

The voice is inherited, its quality depending on anatomical details such as the size of the vocal cords, the size and shape of the cavities of the head, and the consistency of the bones. The Nordic race is said to possess more basses, the Mediterranean more tenors, but this may be merely because the Nordics are larger, and longer vocal cords go with larger bodies. The principal difference between the man's voice and the woman's is that the man's vocal cords are a third longer and therefore vibrate more slowly. It has been alleged (18) that bass is dominant in man to tenor and soprano dominant in women to alto, while the mixture of the two types, with imperfect dominance, produces baritone and mezzosoprano respectively; but the real relations are probably not quite so simple as this picture.

While most musical traits have little correlation with general intelligence, inflection of the voice (not a musical trait in the narrowest sense, since it is equally noted in the speaking voice) is correlated so highly that it makes a better test of the IQ than does school standing and almost as good as the standard mental tests

(235). Inflection shows (1) sensitivity to the need of change and (2) economy, or freedom from random movement in making the change. Tested by delicate instruments, it is found that the intelligent person will (1) vary the inflection of his voice over a wide range and (2) control his inflections so that the rises or falls will correspond to the true meaning of the passage spoken; whereas the dull person will speak in a monotone or raise and lower the voice at the wrong time. The speech deficiencies that go with intellectual deficiency are too familiar to need further comment here.

If the details of inheritance in the musical arts are little known, those of the visual arts are still less, while the remaining arts offer an almost unexplored field.

If a child is asked to draw a picture of a man, the product furnishes a good index of his intelligence (136). It represents merely what he knows—it is not a test of artistic ability, but of whether he is mentally mature enough to realize the need, for example, of giving his man ears and his coat buttons. Apart from this special case, real artistic ability has invariably been found to be related only slightly to general intelligence. The talent for representative drawing, like musical talent, depends on the concurrence of a number of highly specialized traits, and many children of high IQ lack these special gifts. On the other hand there is, as one would expect, somewhat more relation between the IQ and the talent for symbolic drawing, analytic drawing, and caricature.

Probably acting and dancing represent to a marked degree the same sort of capacities for esthetic appreciation and rhythmic motor activity; and on the basis of such examples as the Kemble, Kean, Booth, and Barrymore families, it has been assumed, no doubt with some truth, that these traits run in families through the influence of particular genes.

So little can be said definitely about the inheritance of literary talent that I omit it here.



FIG. 26



FIG. 27

FIGS. 26, 27. MENTALLY DEFICIENT THESPIANS

The effectiveness and zest with which mental defectives put on a dramatic performance suggests that a high IQ is not a prerequisite to success on the stage. These photographs (above, "The Student Prince," below, "The Toreadors") show two of the undertakings of the inmates of the Belchertown (Mass.) State School, and are from Dr. Arthur E. Westwell in the *Proceedings* of the 52d annual session of the American Association for the Study of the Feeble-minded. In some respects the stage director at such an institution departs from precedent: thus Dr. Westwell reports that "If the MS calls for a love scene, the scene is done at a little more than arm's length. We find that such scenes may be done without the characters even touching hands, and with no loss of effect to the performance." Some motion picture directors have not yet discovered this.

CHAPTER XXIV

SEXUALITY

To the inevitable question, "Is it a boy or a girl?", the only correct answer is, "A little of each." The difference is one of amount more than of kind.

It is often remarked that the child inherits from both father and mother, and therefore should be expected to have some of the traits of each. This is of course a misleading way of looking at the facts, since the child inherits nothing from either father or mother, strictly speaking, but is, like them, the product of a stream of germ-plasm which is highly conservative in general plan but changing in detail with each generation, due to the union of two distinct sets of genes and the shuffling of the chromosomes containing these genes at the reduction division which precedes the inception of a new human life.

It was pointed out in Chapter III that sex seems to depend primarily on a level of metabolic activity which, in turn, is determined at the moment of conception by the kind of genes that go into the fertilized egg-cell. It would be expected that there would be slight variations in this process, brought about by the quality and quantity of the genes and their reactions to outside influences, which would lead to slight variations in the result: some individuals would be more male, or more female, than others.

Pushing this idea a little farther, it is easy to imagine that there might be a union of two cells with such a balance of genes that the resulting embryo would not be very definitely one sex or the other, but half way between; and the supposition is strengthened when one actually sees such intersexuals in the adult stage.

It was noted in Chapter I that racial and individual differences make their appearance in the embryo almost as early as the latter is large enough to be examined, and that they are well marked within 10 or 12 weeks from the day of conception. Sexual dif-

ferences have not yet appeared at this time; they begin to develop comparatively late in the fetal life.

This does not necessarily mean that they are any less fundamental than, say, racial differences; simply that the mechanism which produces the differentiation is not quite the same. The secondary sex differences depend in the first place on the action of the reproductive and other ductless glands, particularly the adrenal cortex; hence they can not begin to appear until these glands themselves have been differentiated (under the stimulus of the level of metabolic activity of the fetus), and have begun to produce their internal secretions or hormones. It is the latter that seem to be the main direct agency in producing the common visible differences associated with maleness or femaleness in the child, and they are very active in the fetus and newborn child,—so much so that there is a particular surge about the time of birth, and three newborn girl babies in a hundred show signs of menstruation, while in almost every one of them careful examination will reveal in the vagina at least a few blood corpuscles that have come down from the uterus. The breasts show comparable activity, and may even produce a little milk. Within a few months after birth the reproductive glands seem to have played their first rôle, and they then become quiescent, doubtless with corresponding changes in the other ductless glands, until all are stimulated to another great burst of activity at the age of puberty.

There is thus a remarkable difference between the reproductive system and, say, the nervous system, in relation to the time of activity of the genes.

The nervous system is essentially complete at birth. The nerves still have to be brought into full function by completing their interrelations and in many cases by the completion of a sheath of myelin surrounding each of them, just as an installation of bare electric wiring would require insulation before it could carry a full load of current; but not a single cell is added to the brain after the day that the child is born.

The reproductive system is merely sketched out at birth, and

is not completed until after adolescence, or even after marriage. Its progressive development extends over a whole generation longer than does that of the nervous system.

It seems to be a fair inference that the reproductive system is capable of much greater modification by outside conditions, than is the nervous system. Both are probably capable of more change than is such a simple feature as color of the skin (hair, eyes, etc.), which seems to result from a particularly direct and uncomplicated line of development. In many instances the difficulty of change of an adult trait seems to be proportional to the complexity and indirectness of its development from the germ-cell. The importance of such an inference, in the training of boys and girls, is obvious.

The great majority of individuals who lack full, normal, sexual differentiation are characterized not by any scandalously perverted behavior, but merely by sexual inadequacy. These are the victims both of inherited constitution and of biologically bad surroundings,—wrong education,—the balance and interaction of these factors being here, as usual, so complicated and delicate as almost to defy analysis.

Whatever may be, in a given case, the actual causes of the failure of the child to develop sexually to an advantageous degree, some of the more important results of the failure are the following:

1. Greater susceptibility to the diseases that predominantly characterize the opposite sex (87).
2. Loss of mental efficiency, partly through lack of the drive that a normal emotional life provides, partly through the inferiority complex (which, as someone has said, is often nothing more than a sound sense of values!).
3. Delay or avoidance of marriage and, if married, unhappiness due to mismating, together with increased liability to childlessness.

In detail, the sexual life shows the same range of inherited peculiarities that all other functions do. Among males, failure of the testicle to descend has already been mentioned (p. 109). A rarer anomaly is the existence of an opening on the under side of the penis instead of at its end (hypospadias). This is said to occur in

about one man in 300, and is inherited as a dominant in either sex; of course it can not be expressed by the female, but she can transmit it to her sons.

Differences in the length of the menstrual cycle seem to be partly determined by genetic factors (3) and there are some striking instances, as where a mother and her five daughters all had a 25-day cycle (194). While the cycle averages 28 days, no case has ever been recorded which followed this cycle exactly and without variations, and in most women the divergences are much greater than they themselves realize. Variability is about one-third greater among the mentally deficient than in a group of intellectually superior women, although among the defectives there is no correlation between mental level and regularity of menstruation (305). The assertion (170) that intersexuals menstruate late and feebly but very regularly requires confirmation.

Although in a majority of cases it is claimed that the menstrual flow is regular after its second appearance, there are enough unusual cases, in which it is not established with regularity for some months or years, to make a correlation between irregularity and youthfulness. Late onset of menstruation also means in many instances that it will be irregular later in life, and in general, unusually late menstruation (that is, after physical and mental growth have largely ceased) is to be looked on as an abnormality. It is found in more than average degree among individuals who have mental disease or mental defect in their ancestry (305).

The average age of onset is so variable that it can not be fixed even statistically in any given year, with satisfactory results. In the white race in the United States, any age between 8 and 20 may be entirely normal, as shown by my own studies, although in some cases such extreme ages are abnormal. The average is just under 14, and is probably not so much influenced by climate, race, and economic situation as is usually supposed. The average of a group of 489 Hindu women (61), representing many different castes and races, but in almost every case different climatic and environmental conditions from those in America, was also just under 14, as it was

also in a group of 800 women, mostly Russian Jewesses, studied in New York (219). In this latter group, no differences were found between country-bred and city-bred, nor did removal of a family from one environment to another cause any change. The mentally deficient girls whom I have studied in California show no significant differentiation in age of first menstruation, either as regards race, economic status of father, or whether born in the southern or northern United States.

The age of onset seems to be associated with the level of basal metabolism and to be determined primarily by inheritance, the correlation (308) between mother and daughter being .40 and between sisters .39, in 200 physically and mentally normal families which I studied. The size of the correlation suggests that it is just as much a matter of constitution as is any other anatomic feature such as skull length or bodily stature, and that the influence of the father is just as great as that of the mother. Several cases of one-egg twins who first menstruated on the same day have been reported.

There is, in general, no relation between the age of onset and the intellectual level—that is, idiots and imbeciles do not differ in this respect from normal women (305); though a group of California girls of extremely superior intelligence began menstruating a little earlier than the average (367). Contrary to what is often asserted, there is no relation between age of onset and age of cessation of menstruation. From the age at which a girl begins to menstruate, nothing can be predicted as to whether she will reach the menopause earlier or later than usual (305).

Of the childhood traits which I have studied, teething is the only one that seems to be associated even slightly with the menstrual history of the future, the correlation being .28. Thus early teething is a slight indication of early onset of the menses, while delayed teething is more likely to be followed by late puberty.

Among the minor anomalies is a case of three generations of women in whom menstruation continued during pregnancy, stopping only about the seventh month. All five of the women af-

fects showed some general irregularity (257). Some students have denied that menstruation during pregnancy can properly be called menstruation, holding that this is a contradiction in terms. At any rate, what happens is like menstruation.

Through the type of constitution, width of pelvis, flexibility of muscles, sensitiveness of the nervous system, and similar factors, inheritance influences strongly the ease of childbirth. There are families in which this is a simple matter from generation to generation; others in which the females regularly suffer inordinately in parturition (326). Even the anatomical details are reproduced, so that the old gynecologist who treated the mother for retroversion of the uterus is not surprised to have the daughter come to him, a generation later, with the same complaint. A slight underdevelopment of the reproductive organs is a frequent accompaniment of the asthenic constitution (170) though in general there is little or no relation between the size of a woman's breasts and her body build.

CHAPTER XXV

IS IT HEREDITARY?

Michel de Montaigne, who had an inherited tendency toward gall stones, considered that he had also inherited an antipathy toward physicians: his father, grandfather, great-grandfather and uncle alike detested the medical profession.

Louis XIV and his brother were gluttons, and their sons and grandsons were said to have inherited the same inclinations.

Da Gama Machado knew a woman who had a passion for gambling. Her son inherited this; his daughter in turn received the trait.

M. de Voltaire cited as instances of the inheritance of moral traits the Appii, ever proud and inflexible; the Catos, always austere. The whole line of the Guises was bold, rash, factious, full of the most insolent pride and of the most winning politeness.

"Vespasian's avarice was hereditary."

A. Brierre de Boismont knew a man who saw ghosts; his son inherited the capacity, not knowing that his father also had it. The Old Masters had no doubt that demoniacal possession was inherited in certain families.

Complaint having been made to Caligula that little Julia, two years old, scratched the children who were her playmates and even tried to tear out their eyes: "I see," he chuckled, "she is my daughter."

Marie Leczinska loved her father passionately; her daughter Adelaide inherited the tendency and loved *her* father for that reason, avers Jules Michelet.

It would be equally easy, though more invidious, to pile up an equally foolish series of illustrations from contemporary writers. The common custom of looking over a family, seeing that a trait is present in many or all of its members, and assuming without further discussion that the trait is inherited, proves absolutely nothing.

The only procedure that could be as unscientific is the equally common one of looking over a family, seeing that the trait in question is not reported for any other member, and assuming that it is not inherited.

To form a more intelligent opinion, one must first of all know what one is looking for—that is, must define or identify the inherited trait. The difficulty here is the universal difficulty of the study of heredity—to bridge the gap between the gene in the cell and the trait in the child or adult. Progress is made just in proportion to the accuracy with which these two ends of a long and invisible chain can be tied together.

Once a trait has been identified as something that exists as a unit, or at least something that can be recognized, measured, and followed from generation to generation, the task that confronts the student is somewhat different according as he proposes to deal with a single family—his own ancestry, for instance—or the world at large.

For convenience, the problem may be examined in respect of a single gene in a single family, first. As a start, one will inquire whether it shows signs of being dominant or recessive. The easiest test of dominance is to compare brothers with half-brothers (or sisters, as the case may be). When a parent and his children by one mate show a trait, but the children by another mate do not show it, the trait is not a simple dominant.

The time-honored test for recessiveness is to examine the offspring of cousin marriages. A trait is not necessarily inherited even if it is common in a family; but if it is commoner in the offspring of marriages of kin than in the offspring of other marriages, there is good ground for suspecting that it is an inherited trait involving recessive genes. The rarer a recessive trait is in the population as a whole, the greater is the likelihood that it will appear in a cousin marriage rather than in an ordinary family.

Whether a trait is or is not dominant has a practical significance, in respect of the abnormalities which are the commonest object of study in one's ancestry. If a trait is dominant, a line that is free

from it will always remain free: one who does not show it can not transmit it. If recessive, it may be transmitted though not shown: it may appear at any time in the future of the family. For this reason to say, when only one child in a family has a trait and neither parents, grandparents, nor close collaterals show it, that the trait is not inherited, is unscientific. It may or may not be inherited.

In the case of a rare trait, appearance several times in a small pedigree offers a presumption of inheritance, for the chances are strongly against such a coincidence. In the case of a common characteristic, such appearance proves nothing until it has been checked against other possibilities.

In general, it is not likely that all the children of a family will show any inherited trait. That will happen when both parents have the trait and are purebred for it, if a recessive; when both have it and at least one is purebred, if a dominant. Such a situation is rare in such a mixed species as the human. Generally speaking, the fact that part of the children in a family show a trait and the rest do not show it or show the opposite, is presumptive evidence that the trait is inherited. If all the members of a family show it, one would suspect infection or tradition. For heredity, it proves too much!

On the other hand, if a trait in an individual is due to a mutation, it may not be represented in the ancestry at all—properly speaking it is not inherited—but it will be strictly inheritable nevertheless, and will appear in a certain proportion of the descendants.

A boy (195) was found to be "double-jointed." This peculiarity was unknown in the ancestry, and it did not appear in any of his nine brothers and sisters. When he married, however, he transmitted it to all of his four sons, though not to any of his daughters. The fact that it was unknown in the ancestry evidently can not be used to argue that this trait is not inheritable. Had the boy died unmarried, it might well have been thought that this peculiarity was not hereditary but a mere accident of development. The fact that he transmitted it to his sons suggests, however, that

he carried a sex-linked dominant gene which probably represented a new mutation in that line.

If a trait can be shown to be sex-linked or sex-limited, as it can in most cases if such is the fact, one has at once something definite to work on. It must not be forgotten, however, that either sex may indifferently pass on to the offspring some of the characteristics of the other sex. A man may inherit the color of his beard from his mother; a woman may inherit peculiarities of her breasts from her father (151).

In short, the investigator of a given trait can tell usually without much difficulty whether the trait is

1. primarily determined by a single gene,
2. whether it is dominant or recessive, if it is a simple trait,
3. whether it is located in one of the sex-chromosomes (sex-linked), or
4. whether it is sex-limited, reaching full expression only in the presence of certain internal secretions from the reproductive glands of one sex or the other.

Many, perhaps most, abnormalities can thus be disposed of, for they are frequently simple and due to an alteration in a single gene.

While any abnormality is likely to be inherited in different ways in different families, it is usually inherited in the same way in a single family. If it starts out as a simple dominant, for instance, it is likely to remain so for at least the short period that is covered by an ordinary pedigree study. The average investigator is not so much interested in the theory of the thing, as in finding out how a given trait behaves in his own family.

The average distribution of a single gene in the offspring of any mating may be predicted by making the appropriate algebraic combinations, and may be shown simply in the conventional checkerboard diagram.

It is customary to use capital letters for dominants and small ones for recessives. There is a family, for instance, in which an unusual whiteness of the nails was traced as a simple dominant through four generations (12). Suppose that W stands for this

trait and w for its alternative the normal and here recessive condition. A man with white nails probably received them from only one parent, since the trait is so rare that it may be ruled out of consideration in the other parent's family (excluding cousin matings). His constitution would then be designated as Ww , the dominant trait being received from the father, the recessive from the mother.

He will marry a woman who will be of the normal constitution, ww , not having received this trait from either of her parents. The mating will then be $Ww \times ww$, which algebraically would result in $2 Ww + 2 ww$; that is, there will be equal numbers of children like the father and children like the mother, in respect of this trait.

If a very large number of children could be produced from this mating, there would be found to be just 50 percent of affected and 50 percent of normal individuals. In this mating, as a matter of fact, there will be only a few children, and chance might lead to all of them being normal or all affected, just as in tossing a coin three or four times one might get all heads or all tails by chance although the expected and average result would be equal numbers of heads and tails.

When the calculation is thrown into the familiar checkerboard form, which seems to be easier for most people to follow, one parent is put at the top and the other on the side, like this:

		MOTHER	
		w	w
FATHER	W	Ww	Ww
	w	ww	ww

Here the two paired genes in each parent are separated, so that the results of recombination in the cells can be seen more readily. They will be separated in real life; hence the diagram merely makes it possible to follow in imagination what will happen in fact.

The father's dominant gene for the trait (W) may find a mate in either one of the mother's pair of corresponding genes, but as these are just alike, the result will be the same in either case, namely Ww , or an individual just like the father in respect of white nails. The father's alternative, normal gene (w) may also mate with either of the mother's normal genes, but here again the result will be identical in either case, only a normal child (ww) being produced. The four possibilities are shown in the four squares. By counting the squares one gets the same result as from the simple algebraic multiplication: 2 Ww and 2 ww , or half the children affected, half normal. This is the most probable result in the family. With large enough numbers to get away from chance deviations it would be the actual result.

Those who pursue the question will find that there are six possible types of mating, where a single gene that shows dominance is involved, and each of these types of mating can be represented separately on the checkerboard so that the precise results to be expected from it are evident. These types of mating, allowing for all possible varieties of constitution of the two parents for this gene, are:

$$WW \times WW = 4 WW$$

$$WW \times Ww = 2 WW + 2 Ww$$

$$WW \times ww = 4 Ww$$

$$Ww \times Ww = 1 WW + 2 Ww + 1 ww$$

$$Ww \times ww = 2 Ww + 2 ww$$

$$ww \times ww = 4 ww$$

Each of these combinations, and hence the probable expectation of offspring from each mating, is interpreted readily by remembering that W represents the trait, w the lack of it, and that if it is present even in a single dose it will manifest itself.

By tabulating the results of observed matings in a family, and

then applying to them each of these formulas in turn, the student will find which one best fits the facts. Exactness is not to be expected, in the first place because there is always a chance deviation from the calculated number unless one is working with immense numbers; in the second place because of the possibility of upsetting the ratio in various ways that have been described repeatedly in this book: modifying genes may interfere, a child which would later have shown the trait may die before it appears, and so on.

If one gets to dealing with different races the picture is still more complicated and the accepted facts may be overturned. I have already given examples of this in connection with such everyday traits as hair curliness and skin color. For instance, I know of a family in Honduras: a Texas Nordic has married a light-colored native girl, Indian with a slight Spanish admixture. They have three children, each of a quite distinct tint but all notably darker than the mother, and of course much darker than the blonde father.

A striking case in the opposite direction is reported from South Africa (101). A fair-haired, blue-eyed Danish sailor married a native woman. A son is quite Bantu in appearance, with dark skin; a daughter is olive-skinned with light hazel eyes and European type of hair. She is married to a Dutch man with light hair but dark brown eyes, and they have three children. Of these, the eldest son has blue eyes and dark brown hair; a second son has hazel eyes, brown hair, and the thick lips of the native; a daughter has blue eyes and flaxen hair, though the Bantu type of countenance with thick lips and a short, wide nose. This is a case of atavism—a word that, like *Mesopotamia*, may be “such a comforting word,” providing one does not try to make it explain anything. In this case it may be taken literally as meaning the reappearance of traits possessed by a grandfather. Obviously, anyone who would attempt to fit the family I have just described into a simple Mendelian checkerboard would get into difficulties.

The possibility of illegitimacy or adultery always enters into a pedigree, unless one knows the stock personally, and it may falsify

the records and produce unaccountable results, as in the musical family described on page 241.

The checkerboard can also be used to express all the complications of sex-linked and sex-limited heredity, and to show the results of combinations of two, three, or more different genes. Examples of such uses will be found in any text-book of genetics. Most parents will have no need for more effort than that necessary to trace the distribution of a single peculiarity in their own family.

But most human traits, particularly the more normal and important ones, are compound and do not yield readily to such an analysis. In many instances, as has been shown in almost every page of this book, one must for the present at least give up the attempt to say exactly how they are inherited, but one may hope to speak more positively as to whether they are or are not inherited.

For this purpose it is usually necessary to examine the trait in a number of different people in quite different surroundings. If the trait is constant in all these cases, and if it can not be explained readily in any other way, one would suspect that it is part of the original nature of the individual. The belief is strengthened if the trait is one that appears early in life, as does musical ability for instance.

In more pretentious research, large numbers of individuals are studied statistically by means of the 'calculus of correlation. Instances of this have been quoted throughout the book. Short-sightedness will serve as a good illustration, since it is a common trait and one that is easily ascribed to the effects of the surroundings, as for example over-strain of the eyes in near work, hence not heredity.

If in many cases the resemblance between parent and offspring, and between brother and sister, is found to be just about the same for short-sightedness as for eye color and other traits that are admitted to be inherited; if short-sightedness is found to be just as characteristic of people who live outdoors and can not even read and write, as it is of the studious scholar or the seamstress in the sweatshop,—in other words, if there is no correlation between the

degree of short-sightedness and the environmental condition that might be expected to influence it; then it is more than a suspicion that short-sightedness is a structural defect of the eye, dependent on the development that is determined by the genes, and not merely on the abuse of an organ that was created perfect by a beneficent Creator. It can not be called a certainty, for certainty does not exist in science: it is found only in fundamental theology, in the judgments of adolescents on their parents, and in schemes to break the bank at Monte Carlo.

Finally, the simplest and most decisive test is often found in a study of twins. Identical twins, being merely halves of the same individual, will normally have an inherited trait in the same degree. Ordinary twins, though born and brought up in as close association and under as constant surroundings as identical twins, will not be any more alike than ordinary brothers and sisters.

If identical twins are more nearly alike in respect of a trait than are ordinary twins, one has evidence that it is an inherited trait. The proof is made still stronger—almost irrefutable, in fact,—if the resemblance persists in identical twins who have been separated in infancy and brought up in different surroundings. If identical twins differ markedly in a trait, it is probable that the trait is not inherited but is a product of training and habit.

CHAPTER XXVI

THE ORIGIN OF NEW TRAITS

The child has blue eyes, or a hare lip, or a high temper: so did its father and grandmother before it. There is no difficulty in accounting for this trait in the child, by ascribing it to heredity.

But sometime, somewhere, this trait must have appeared in the ancestry for the first time. Even if it were supposed to go in an unbroken line through all the ancestors as far back as men were men; back to the dawn man who came down out of the trees to walk on his hind legs, and still beyond; yet the blue eye, or hare lip, or high temper, surely can not be traced through all man's lowly forebears to the original cell that introduced life to the globe.

Where did it start?

Most of the variations in which a child differs from its near ancestors are the effects of combinations of existing traits—they are merely the evidences of hybridization. The potentialities were present in the genes and the proper combination of genes, which had not occurred before in the recent history of the family, gave them expression.

But beyond this, there are actual changes taking place in the genes all the time, and these result in the production of new traits that have never before been seen in that particular line. However, as these changes are presumably of a simple physical or chemical nature, the amount and direction of them are limited by the possibilities of the medium.

To take a simple illustration, water is a compound consisting of two atoms of hydrogen and one of oxygen, H_2O . It is a definite thing, not easily changed chemically. If it is changed, by the addition of other atoms, it is changed in definite and predetermined ways. The addition of one atom of oxygen produces an entirely new compound, H_2O_2 or peroxide of hydrogen, with entirely different uses—of less value for the production of pineapple sherbet, but

more useful for turning nut-brown maidens into synthetic blondes. The important point in this connection is that the addition of one atom of oxygen to water always produces the same thing, and never anything that differs from this product in the slightest degree.

So, it appears, the number and nature of the changes that can take place in the genes are limited by the nature of the genes, and one therefore finds the same new trait, that is, a trait which was not in the immediate ancestry, appearing over and over again. Albinism occurs in different families, tribes, and races (likewise in other species of animals), year after year, and has done so since the beginning of history. It is evident that a simple change in the germ-plasm, which occurs frequently, produces precisely this one result in the completed child.

This does not mean that the mutation of a gene is always in the same direction: merely that there is a limited number of directions in which change is possible.

Many mutations seem to be in the nature of a loss of something, but this is by no means always the case. Again there may be reverse mutations—thus brown eyes might change to blue, and later in the same line might change back again to brown. Once more, a change in the same gene may at different times produce different results, dependent no doubt on linkage and the presence of complementary and modifying genes. Thus, to illustrate by a purely imaginary example, the mutation which today changes brown eyes to blue might tomorrow leave the eye color unaffected and change the color of the hair on the head. This conclusion (based on experimental evidence) follows logically from the fact that the genes all work together in development, pouring their chemicals into the cell in a very small area. The surprising fact is not that they modify each other so markedly, but that they do not do it much more.

If one asks what the nature of this change in a gene is, an answer can not now be given, except to point out that the genes are probably something like protein molecules with an exceedingly complex physico-chemical constitution, and that it would be surprising if changes did not occur frequently in such an intricate and delicately balanced constitution.

It has even been argued that all genes ought to be expected to change sooner or later, just as an atom of radium changes in the course of 2,000 years or so until it ends as a dross of lead. As the radium atom "runs down," so one might expect such an active chemical structure as the gene to "run down", although the "life" of most genes is long—probably several thousand years at least.

Due to their constitution, it might be expected that some genes are more stable than others. In lower animals, and in plants, exceptional genes have been found which have been calculated to have a life of only a few years—in other words, a mutation will be expected as a matter of routine after a few generations. Others are distinguished which have a probable life of 50 or 100 years.

Apparently it is the rule that only one mutation occurs in an animal at one time. As the human cell contains many thousands of genes, a mutation is not often noticed. Many of them probably do not appear at all, since they kill the cell in which they occur; the effect of others is swamped or smothered in development, or is so slight as to be unseen.

To estimate the frequency of the occurrence of mutations in children requires some speculation, but a first attempt has been made (67), by calculating the frequency of a rather common abnormality, the absence of the palmaris longus muscle on the under side of the forearm. By some complicated and ingenious figuring it is concluded that a mutation which results in the loss of this muscle occurs once or twice a year in the entire population of the United States. It is a little less frequent among Negroes, a little more frequent among Russians.

By the same process, the mutation that produces syndactyly (the joining together of the third and fourth fingers, or toes,— "web fingers") is calculated to occur about once in 2,000 genes, and the same is true of polydactyly—the inheritance of an extra finger or toe.

It has been widely believed that such changes are due, at least in some cases, to the action of some force outside of the body. In a few extreme cases, it has been possible to shock the genes by direct

action, in such a violent way as to provoke a change in the constitution of one or more of them. This would naturally be carried on through cell divisions like any other mutation, and produce changes in the children born from that germ plasm.

Thus mice and insects have been X-rayed so as to produce inheritable changes. There are a number of other, more doubtful cases, involving serums (supposed to act through the secretions of the internal glands which they contain), alcohol, and other chemicals. There is no reason to suppose, in advance, that a powerful shock which reaches a gene may not upset in some minute particular its marvelously complicated and sensitively equilibrated constitution; it is simply a question of evidence—of seeing whether or not it does. Granted that in a few cases it does, yet it must be pointed out that these shocks are of so extraordinary and severe a nature as never to occur in daily life. Hence, great as their theoretical importance may be in leading to a better understanding of the mechanism of heredity, they are of no practical significance in demonstrating how it happens that Betty is a blonde when her ancestors were brunettes.

The mutations which are provoked in lower animals by application of X-rays or radium are exactly like the mutations that are appearing spontaneously in these animals from time to time; hence it is assumed that the process involved in each case is the same. It may be that when a gene reaches a certain stage in its existence, cosmic radiation provokes a mutation, and that at an earlier stage of its existence direct application of the more violent X-ray hastens this event. Since the X-ray (or any similar agent) reaches the whole testicle or ovary, yet may cause a mutation only in a single cell, and only in a single gene in that cell, one must believe either that the effect of the X-ray is incredibly minute and local, or else that this particular gene mutates because it was about ready to mutate and others were not. Such speculations must be supplanted by further research.

In the work so far done, it is important to note (1) that there is no tendency for a whole group or block of genes, lying beside each

other, to mutate all together. It is a case of one at a time, as usual. (2) The mutations appear to be at random. (3) Most of the induced mutations, like most of those occurring naturally, are harmful or fatal.

I insist on these points, in the present connection, in the first place because they show that there is no prospect at present of being able to alter human heredity at will by provoking mutations. In the second place, they furnish a caution as to the use of X-rays medically. Prolonged irradiation of the ovaries of a non-pregnant woman, stopping short of the production of permanent sterility, may not affect the woman or her children, and yet might produce mutations which in some future generation would appear. There is some evidence from experiments on lower mammals that this is the case.

It is the rule that only one of a pair of genes mutates at a time. If it should mutate to a dominant condition, it could make its effects visible in the next generation. Usually, however, it mutates to a recessive condition, and in this case will not produce any manifest effect until it meets with another recessive like itself. If it is a common mutation, this meeting might occur in the next generation. If it is a rare one, it might not occur for many generations, until descendants of the original possessor began to intermarry. Hence it is conceivable that mutations are now being produced in X-ray laboratories, from which the race may begin to suffer only some centuries hence.

Incidentally, this offers an argument against some of the alleged explanations of "racial degeneracy." If it is averred that the parent's alcoholism, for instance, changes the germ-plasm to produce defective descendants, the objection at once arises that, from all that is now known, such a mutation, if it existed (there is no evidence that it does), would be a change only of a single gene, and that probably to a recessive condition. In this event it would not produce visible effects for generations. But the effect that it is alleged to produce is a more or less general one in the offspring. The conclusion is that substances like alcohol probably do not

deteriorate the race by affecting the inheritance, but in some other and more direct way as by circulating in the mother's blood and thus poisoning the fetus during pregnancy.

If a single heavy shock will mutate a gene, it has been argued that a long continuation of light stimuli might produce the same result, just as constant dripping wears away a stone or a column of soldiers marching across a bridge in step may shake it to pieces. This argument is advanced by those who seek to show that outside circumstances may bring about changes in heredity. There is no evidence in favor of it, but merely as a speculation it seems to be opposed to the facts.

Like any figure of speech, it can be met by others of contrary import. The great Pyramid of Egypt could be overturned by a sufficiently strong push, and would then come to rest in a new position of equilibrium, where a similar great force would be necessary to upset it again. A boy might shoot peas at it from a blow-gun for a million years, and while the total force of impact of those peas, added together, might amount to the force necessary to upset the sepulchre of Cheops, no one will argue that at the end of the 999,999th year it would actually rise on one edge and topple majestically upon its side. If the gene is thought of as molecular in nature, the illustration I have given more nearly represents the facts than does the illustration of water wearing away a stone. It is a case of all or nothing.

Finally, apart from mutations in a particular gene, much variability is introduced by changes in the balance of the chromosome material, due to irregularities in its division.

Like all other cells, the germ-cells prolong their existence by dividing incessantly. Each time any cell in the body divides, its chromosomes split lengthwise and half of each chromosome goes to one of the daughter cells, so that the daughter gets her full share of the ancestral heritage—that is, she gets a half interest in every gene and this half interest soon grows to be as large as the original.

In the splitting and subsequent recombination of the chromosomes, there is room for accidents; and they happen from time to

time. One chromosome may lag behind in the pairing, and fail to arrive before the gates are shut; so that the two daughter cells, instead of having each 48 chromosomes, have 47 and 49 respectively. Or one of the chromosomes may break and half of it be lost, the other half sticking to a neighboring chromosome and continuing with it indefinitely. There are numerous other casualties of this sort which have been watched under the microscope. They vary in detail but their general effect is the same—to upset the normal chromosomal balance and to produce a cell that has either more or less than its ordinary share of genes. The result is that the child produced from this cell is not what it would have been had the cell division been normal. Often the change is so great that a living child can not be born. In the case of small changes, the child develops normally but with smaller or greater variations from the ancestry.

Probably there are other causes producing new traits, which have not yet been discovered. So far, however, the appearance of new traits is largely along two lines (apart from the production of changes artificially through extreme shocks, which is so rare as to have no practical importance, and apart from the recombinations of old material which are incessantly going on and which account for most variations):

1. Local changes (mutations) in definite genes.
2. Changes of chromosome balance, due to irregularities in cell divisions.

The progress of evolution, and the appearance of superior individuals, depend largely upon such changes. But they produce unfavorable results much more frequently, and the reason for this is almost self-evident.

The germ-plasm which produces babies is possibly the most complex thing known. It is the product of innumerable millions of years of slow evolution. In each generation, all sorts of new combinations have appeared, until every possibility of the germ-plasm must be very nearly exhausted. The favorable ones have survived most frequently, because they were favorable; the unfavorable ones have died with their possessors.

Hence the present constitution of the genes represents a condition, relative to its complexity, of great stability: it has been produced by an almost infinite process of trial and error, and the best product, preserved in each generation, has been perpetuated and improved just the slightest bit more in the generation following.

Now any random change in such machinery (and all changes of this sort are probably random, subject to the limitations on which I have insisted, that are set by the nature of the material) is more likely to be harmful than to be helpful.

As a crude illustration, one might take a complicated machine of human production. If my least child, to demonstrate his manly vigor and freedom from inhibitions, swings his birthday-tool-chest hammer down a few times on my typewriter, the resulting changes may produce an improvement in the machine, for which the manufacturers will gladly pay me enough royalties to subsidize a great deal of research in human heredity.

It is distinctly more probable, however, that the last state of that typewriter will be worse than the first, and that I shall have to buy a new one at my own expense.

Similarly any random mutation affecting a complicated structure like the human eye may produce better vision; it is distinctly more probable that it will merely impair the vision that existed previously (in the ancestry). Hence the continual crop of defects and abnormalities of the eye—and of all other parts of the body.

In sum, new traits are arising in every generation, and in every part of body and mind. Occasionally one is an improvement; often it may be indifferent or negligible; still oftener it is a misfortune. It may even prevent the development of an embryo altogether.

Mutations that show dominance are relatively rare in all animals. Their apparently greater frequency in man than in other animals may be due merely to the fact that natural selection does not weed them out so rapidly. Normally, injurious dominant mutations are more subject to selection than are injurious recessive, hence less persistent.

Most changes are recessive, the normal behaving as dominant. In other words, the change occurs in only one of a pair of genes, and the one that is unchanged dominates over its altered mate.

At the next generation these mates are separated, and the altered one starts out on a career that may take it all over the world, through many generations, while it remains unnoticed. It can not show itself until it finds one altered in the same way as itself.

Its survival at all, during the first generations, is due mainly to chance—that is, whether it happens to be kept in the germ-track or thrown out; whether the cell in which it is located is continued by conjugation and division, or dies unmated. Assuming that the mutation is not particularly unfavorable, so as to handicap its possessor, it has been calculated that roughly one mutation in 50 will survive for 100 generations, and at the end of that period, say 3,000 years, will be represented in 50 individuals (109).

After it has thus run the gantlet of chance, it begins to multiply due to mating with other genes like itself, and its fate thenceforth is dependent on natural or artificial selection. If it handicaps its possessor it will disappear, or tend to become negligibly rare. If it is an advantage, it may spread quite rapidly. If, like most mutations that actually survive, it is of no particular consequence one way or another, it will hold its own, or fall or rise according as it may happen to be linked advantageously or disadvantageously with other genes,—usually through being in the same chromosome with them.

If a mutational peculiarity appears today in some newborn baby, it represents a mutation that occurred, in all probability, before the discovery of America—more likely, long before the beginning of the Christian era.

Even if an abnormality has quite a start, it may die out rapidly. Thus in a case (106) of hair defect, in which individuals had only short down on the head, eyebrows and lashes lacking, nails abnormal, there were 15 affected persons in three generations. At the time of record there were only two such left, both old men, and at their death the abnormality would disappear. In such cases the disappearance may be due partly to sexual selection, partly to lessened vitality of the affected individual.

Contrary cases are equally striking. Short-fingeredness does not seem to be any handicap in survival. In one pedigree, it was found that the affected regularly married in larger proportion than the unaffected; in another it was found that they had an excess fecundity: a normal woman had 45 descendants, while an affected woman in the same family had 99.

Theoretically, any abnormality ought to handicap its possessor at least slightly in the long run. But in human conditions this handicap, even if heavy, may be offset by some special value. Thus in thoroughbred race horses in England there is a tendency to burst blood-vessels—one of the severest handicaps that could be imagined. It has continued, because it is evidently linked with something valuable, and breeders can not get rid of it. Similarly, corn-breeders calculated that by strict selection and inbreeding to get rid of all bad qualities, then hybridizing to produce vigor, they could create a synthetic maize that would have all of the possible virtues and none of the conceivable vices of the old stock. They have done well, but not so well as they had hoped. When they came to eliminate all the defects, they found that some of these were tied up with valuable qualities, perhaps from being in the same chromosome; and the one could not be ejected without losing the other. That the same situation occurs in human families, could be suggested by historic examples and by every-day observation.

It will be seen that if a recessive mutation appears in a family that travels widely, whose members are as likely to marry a thousand miles from the old home as to wed a next-door neighbor or second cousin, this trait may again be lost to sight, as the two recessive genes necessary for its expression separate; and it may continue hidden for generations more.

On the other hand, if it appears in an isolated community where there is a deal of inbreeding, it will soon become spread through all the members of the community. In this way one finds populations in mountain valleys, or isolated by other barriers—those of race, language, and religion included—which show a strong resemblance

to each other, or at least are marked by the common possession of a number of traits not often seen elsewhere. But as such inbreeding becomes less and less frequent with the development of transportation and the increase of travel, it is more and more likely to make for the wider dissemination but slow visible spread of mutations (289).

As I have shown through this book, normal characters are compound—they are the product of numerous different genes working together. An abnormal character is frequently the result of a single mutation in one of these genes. Therefore abnormal characters are distinguished in many cases by being due to a single gene; or in such conditions as mental diseases, perhaps to the bringing together of several such unfavorable mutations. For the same reason, normal characters show dominance less frequently, abnormal ones more frequently.

CHAPTER XXVII

THE CHILD'S HEREDITY

The baby who was severed from his mother, wrapped in warm blankets, and started for the hospital nursery on page 1, has grown up in the intervening 271 pages. He is now old enough for his endowment to become manifest, so that it can be inventoried with fair accuracy.

His genes have produced, not exactly out of nothing, as does a conjuror, but out of the simplest materials, as did the French cook who boasted that he could prepare fifteen different dishes from a nettle-top, a whole child, like every other one in general, unlike every other one in particular.

This child, however, can not be thought of as a machine, made from inert metals and set down to work unmolested, as a clock may be wound up and placed on the shelf to tick until it runs down.

He would be more fitly compared—if all comparisons were not so simple as to be futile—to a whirlpool in the stream of life, animated by the ceaseless current, little changed by sun, wind, or rain; yet taking a certain course from the banks around it and perturbed or altered in outline by a tree or stone falling into it.

He is, more literally, a part of the living material of the world; a part connected by blood relationship with every other part; a part carrying on constant activity which is dependent primarily on its own internal forces, yet pushed slightly in one direction or another by the impact of external forces; a part that is constantly interplaying with its surroundings, so that the two are scarcely extricable even at the most careful examination with delicate instruments.

The child is an envelope surrounding a few strands of chromatin that are part of a network stretching all over the globe. Starting in thousands of genes strung together into a little bunch of chromosomes derived from the father and a similar bunch derived from the mother, and through them from a line of ancestors reaching back to

the beginning of life, the child develops through the interaction of these genes, along predestined lines.

At every step of this intricate process of development, the direction of the next step is determined by the give-and-take of the two inseparable factors—the organic processes of the cell, and the outside world in which these must act. Any extreme change in outside conditions may alter or kill the cell; but under what may be called standard conditions, that is, the ordinary range to which the cell is likely to be subjected, and to which its ancestors have been subjected in past generations, the process of development goes ahead in a standardized way, little affected by fluctuations in its surroundings.

) In each generation the stream of heredity is changed by the arrival of a new current—the introduction of a new set of genes in the mating of the parents. Apart from this, there is an occasional, spontaneous, internal change of a gene (mutation); but this can not be predicted; it can not be caused at will along desired lines; hence there is no prospect at present that the germ-plasm can be altered in any way that will be useful to the parent. Most of the spontaneous changes are harmful if not deadly.

For the student of heredity, the child may be for a moment merely the sum total of all his genes. At all other times he is a child, who can only be considered as a whole; who thinks as a whole, acts as a whole, lives as a whole. When a part is separated out for study, whether it be leg or lung, whether it be mind or body, one has the part: one no longer has the child. The brain of N. Lenin has been cut into 31,000 slices and preserved for the study of posterity, but it is no longer a human brain,—it is merely a collection of microscope slides. Similarly little Eugene can not be split up into fragments or analyzed into ingredients without ceasing to be a boy. It is the whole child which remembers an early picnic, just as much as it is the whole child which falls off the chair.

The student of heredity is obliged to study a piece of the child at a time, as is any scientist; only the artist can seize the child as a whole. But if the student forgets that he has merely a piece of the

whole, and that the child is something more than a collection of pieces—is an integrated personality, in fact—he is losing touch with human nature.

The convenient habit of studying a piece of the child at a time was largely responsible for the concept of Unit Characters, a survival of the old vitalistic idea that all the traits of the adult were somehow folded up in the fertilized egg cell, waiting to bud out; and that the unlimited microscopist whom scientific men are fond of imagining could have picked out in this little drop of jelly the germs of the future red hair, bow legs, and lisp. A little earlier, students tried to figure out how the characters of the adult packed themselves into the germ-cell to be passed on to the next generation; the mythical representatives of these characters were represented as promenading through the arteries, waiting a chance to come to rest in the germ-plasm and prepare for the resurrection; and when the blood of an ox was transfused into an infant, a French writer anxiously inquired what was going to become of the particles that would produce horns!

The greatest change that has come over the study of heredity is that it now starts from the other end, and thinks of a bundle of genes operating on the surrounding material of the fertilized cell, through developmental impulses and the establishment of levels of activity, all of which interact but end in producing a child that is very close to the original pattern.

The fact that the interaction of these genes and their interplay with the outside world results in a variety of products has been exaggerated by some recent writers, who talk as if the product of a gene offers many alternatives and that it is largely a matter of surroundings and therefore presumably within the power of man to determine whether a given gene shall produce white or black, small or large, one or two. In practice this idea turns out to be quite illusory. The possibilities of a gene are limited, and they have been more thoroughly tested in man than in almost any other animal, because he has subjected himself to a wider range of conditions.

The principles of heredity are presumably the same in all life, and human heredity can best be understood by a knowledge of experimental breeding of lower animals and of plants. But it must not be supposed that the evolution of any two groups is necessarily along the same lines. Each has its own potentialities. From a study of a bed of oysters, no one can predict what will be the most probable line of development of a hive of bees; and it is equally dangerous to speculate, from fruit-flies and maize, from ants and mice, on the potentialities of a human baby. The baby is entitled to be studied on his own account, as a unique creature. The parent has always studied him in that way. The scientist must do the same.

But if the parent can not be offered any sort of hocus-pocus that will enable him to change the nature of the product of the genes, he may often change the degree of development of the genes without any difficulty. These do, it is true, set a limit beyond which development is not possible. If they have sketched out a five foot man, not all the food and exercise that the human body can endure will make it into a seven foot man. If they have laid down an IQ of 75, not the most industrious tutor can raise this to an IQ of 150. But taking the genes as they are, the product of one can be encouraged, the product of another checked: this is education. The second will not stop short of a minimum; the first will not go beyond a maximum; but within these limits there is room for an amount of selective development that the world has rarely seen and that the ordinary educator scarcely conceives.

Of course this affects only one generation; the results will not be passed on to the next. But the rising generation is the one with which the parent is most urgently concerned; and in view of the crudity of the treatment meted out to it at present, it is probably a good thing that one generation can not brand all of posterity with its mistakes, but that the next one has a chance to start with a clean slate and make a better job of it.

Every child, even the dullest, has more talent than is now brought into expression—just as he also has more bad traits than commonly

get into action. The wide range of human characteristics means that no child has an even level of endowment; even the superior one is only, like Setebos, "stronger in most things, weaker in a few." It is certainly an exaggeration to say, as Charles Spearman does, that "Every normal man, woman, and child is, then, a genius at something as well as an idiot at something." In the first place it is a misuse of the words genius and idiot; in the second place, it is too reminiscent of the ancient idea of compensation, and overlooks the demonstrated correlations of good traits—correlations which, even if sometimes small, are regularly positive. But there is plenty to work on in any normal child. Proper education—that is, the provision of proper surroundings for the development of the genes—will profit the best endowed child even more in proportion than it will profit mediocrity; but it will profit them all.

Maladjustment makes misery; therefore one must know the weak and strong points that heredity provides, and put the child in a place where he will be happy and prosper. There is such a place for everyone, even though for a few it may be the asylum or the penitentiary. It is a mistake to think that this policy will make for defeatism and an inferiority complex; it is the opposite policy, the policy of pretense and closing the eyes to the fact, that makes difficulties. Even those who aspire, with W. E. Henley, to be *Invictus* should want to know their strong points and cultivate them, in order to get that recognition which seems to be the chief aim of human life. It is pathetic to see how happy a child sometimes is, when he is brought to an institution for mental defectives, where he is competing only with his equals, and where these equals think that there is something at least, in which he excels and by which he can win their approbation.

There are two common, but partial, views: (1) that heredity is a personal possession of which one may be proud, as surpassing the common herd: just as one has a bigger automobile, a fatter bank-account, or a flashier diamond than the neighbors, so one may also have a better heredity. (2) That it is a personal misfortune to be dreaded, a spectral hand reaching out of the dead past to blight

life's happiest moments, to cut off or drive mad its helpless victim at the height of his usefulness.

The biologist will not share these fantasies. Heredity must rather be thought of as a condition of life itself, neither modifiable nor extinguishable; as something with which the individual must work just as he does with gravity. He can annihilate gravity, so far as he is concerned, only by annihilating himself; he can cease to be a part of heredity, only by committing suicide. But just as he makes gravity work for him instead of against him, so he makes his inheritance useful instead of harmful.

Heredity, then, is neither a cause for invidious pride nor a ground for despair. It is simply a fact to be dealt with. If a man thinks of himself as an eternal perpetual-motion machine, then he will realize that he can adapt himself to circumstances. If he can not run in high gear he may have to go into intermediate, but he can still keep on going. If he can not run on distillate he may have to get the best quality of gasoline; but then the cylinders will pound regularly.

In line with this picture, it is sometimes argued that intelligence is not at all the ability to adapt oneself to surroundings, as I have defined it at the beginning of Chapter XV: on the contrary it is the ability to adapt the surroundings to oneself. It is only the idiot who adapts himself to his surroundings.

This of course is merely juggling with words, and can scarcely obscure the real facts. "If General Goethals had been satisfied to adapt himself to conditions, we would have had no Panama Canal. If Edison had the adaptation method, we would have had no electric light," is the assurance. These verbal quibbles have been the bane of science; when one brushes them aside and comes to grips with the facts, the latter are usually recognizable. If W. C. Gorgas had adapted himself to conditions by sitting down on the isthmus and letting the mosquitos kill him, there would have been no canal. He adapted himself to conditions by killing the mosquitos first. In the first case, he was adapting himself to the mosquitos' conditions; in the second case, he was adapting himself to the building of the

Panama Canal. The latter is just as much a condition as the former. A man is entitled to pick out his own conditions. His intelligence is shown by choosing conditions that will favor the progressive evolution of the race.

The greatest opportunity a man ever has to exercise this choice is in the selection of a set of genes to add to his own for the creation of children.

This is the final test of intelligence.

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